UN environment
Environment and Trade Hub
Technology and Management Centre for Development
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Trade in Environmentally Sound Technologies:

Implications for Developing Countries

Citation

United Nations Environment Programme (2018). *Trade in environmentally sound technologies: Implications for Developing Countries*.

Environment and Trade Hub, United Nations Environment Programme

Technology and Management Centre for Development, University of Oxford

Norwegian University of Science and Technology

This project is funded by the European Union

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Acknowledgements

The report was commissioned by the Environment and Trade Hub of the United Nations Environment Programme (UN Environment) and implemented by the Technology and Management Centre for Development of the University of Oxford. It is a key output of the Environment and Trade Hub's project on 'Trade in Environmentally Sound Technologies', funded by the European Commission.

The report has been produced in collaboration with the Norwegian University of Science and Technology (NTNU) and individual contractors.

The project was managed by Ying Zhang, Programme Management Officer of the Environment and Trade Hub (UN Environment), under the overall guidance of Anja von Moltke, Head of the Environment and Trade Hub (UN Environment) and Steven Stone, Chief of the Resources and Markets Branch (UN Environment). Substantive contributions were provided by Rashmi Jawahar Ganesh, Keith Alverson, Mahesh Pradhan, Qing Xu, Man-Mei Chim.

Professor Xiaolan Fu led the research team, supported by Shaomeng Li (lead on trade flow analysis) and Giovanni Pasquali (lead on analysis of challenges and opportunities, supported literature review and data analysis) from Oxford University. John Hermansen, Haley Knudson, Christian Tangene and Mahdis Moradi from NTNU led the sustainability assessment and supported the analysis of challenges and opportunities. Mahesh Sugathan led the mapping of negotiation history and the analysis of trade governance implications, supported by Anirudh Shingal (European University Institute; Indian Council for Research on International Economic Relations), who also contributed to the data analysis. The report received important contributions from Laura Rival from the Oxford University. Final editing and revision was done by Ying Zhang (UN Environment), Kerstin Wonka and Stacey Mills (UN Environment).

UN Environment would like to thank the following experts and colleagues for their review and contribution: Aik Hoe Lim (World Trade Organization), Karsten Steinfatt (World Trade Organization), Ying Yan (World Trade Organization), Rainer Walz (Fraunhofer Institute), Jing Zhang (Nottingham University Business School), George Essegbey (Science and Technology Policy Research Institute, CSIR), Quan Zhao (International Trade Centre), Yanhua Liu (China National Climate Change Expert Committee).

Administrative support was provided by Ardeshir Zamani (UN Environment), Selome Tadesse Worku (UN Environment), Fatma Pandey (UN Environment) and Catherine Kamau (UN Environment). The layout was designed by Jessica Hyne, who also supported communication and outreach of the project. Additional support in the layout was provided by Diana De León.

UN Environment would like to thank the European Commission for the financial support provided for this publication and guidance from Emmanuelle Maire, Javier Arribas Quintana, Bojan Grlas, and Emmy Korodima, from Directorate-General for Environment of the European Commision.

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Acronyms and abbreviations

ALADI	Latin American Integration Association
APC	air pollution control
APEC	Asia-Pacific Economic Cooperation
C/R	clean up or remediation of soil and water
CETA	EU-Canada Comprehensive Economic Trade Agreement
CO2	carbon dioxide
CPC	United Nations Central Product Classification
CSP	concentrated solar power
CTE	Committee on Trade and Environment
EAC	East African Community
EGA	Environmental Goods Agreement
EKC	Environment Kuznets Curve
EPP	environmentally preferable product
ES-CE	environmental consultancy and engineering services
EST	Environmentally sound technology
EST-EG	goods related to environmentally sound technologies
EST-ES	service related to environmentally sound technologies
EUR	Euro
EU	European Union
EVSL	Early Voluntary Sector Liberalisation
FTA	free trade agreement
GATS	General Agreement on Trade in Services
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GPA	Government Procurement Agreement
HS	Harmonized System
IIT	intra-industry trade
ILO	International Labour Organization
ITC	International Trade Centre

LDC	**least developed country**
MFN	**most-favoured-nation**
OECD	**Organisation for Economic Co-operation and Development**
PPM	**process and production method**
PV	**photovoltaic**
R&D	**research and development**
RCA	**revealed comparative advantage**
RE	**renewable energy**
ROW	**rest of the world**
RTA	**regional trade agreement**
SAT	**Sustainability Assessment of Technology**
SDG	**Sustainable Development Goal**
SHWM	**solid & hazardous waste management**
SMEs	**small and medium-sized enterprises**
TiSA	**Trade in Services Agreement**
Trade SIA	**Trade Sustainability Impact Assessment**
UK	**United Kingdom**
UN	**United Nations**
UN Environment, formely UNEP	**United Nations Environment Programme**
UNCTAD	**United Nations Conference on Trade and Development**
UNDESA	**United Nations Department of Economic and Social Affairs**
UNEMG	**United Nations Environment Management Group**
UNESCWA	**United Nations Economic and Social Commission for Western Asia**
UNFCCC	**United Nations Framework Convention on Climate Change**
UNIDO	**United Nations Industrial Development Organization**
US	**United States of America**
USD	**United States Dollar**
WHO	**World Health Organization**
WTO	**World Trade Organization**
WWM	**wastewater management**

Executive Summary

Trade in environmentally sound technologies offers triple win opportunities for environment, prosperity and development.

The Paris Agreement on Climate Change and the 2030 Agenda for Sustainable Development have been game changers in the global landscape of policies regarding environment, climate and trade, acknowledging the strong interlinkages and potential synergies between the different areas.

Environmentally sound technologies (ESTs), often also referred to as "clean" technologies, are technologies that reduce environmental risk and minimize pollution as well as energy and resource use and are essential in the fight against climate change. They also contribute to a number of Sustainable Development Goals (SDGs) such as goal 7 on energy, goal 8 on economic growth, goal 12 on sustainable consumption and production, and goal 13 climate action.

Trade liberalization can further facilitate market creation and expansion for ESTs and generate opportunities for companies, particularly in developing countries, to participate in regional and global value chains. Increasing trade in ESTs can offers a triple win by promoting economic development, industrialization, job creation and innovation while simultaneously enabling countries to more efficiently access the technologies needed to improve their environmental performance.

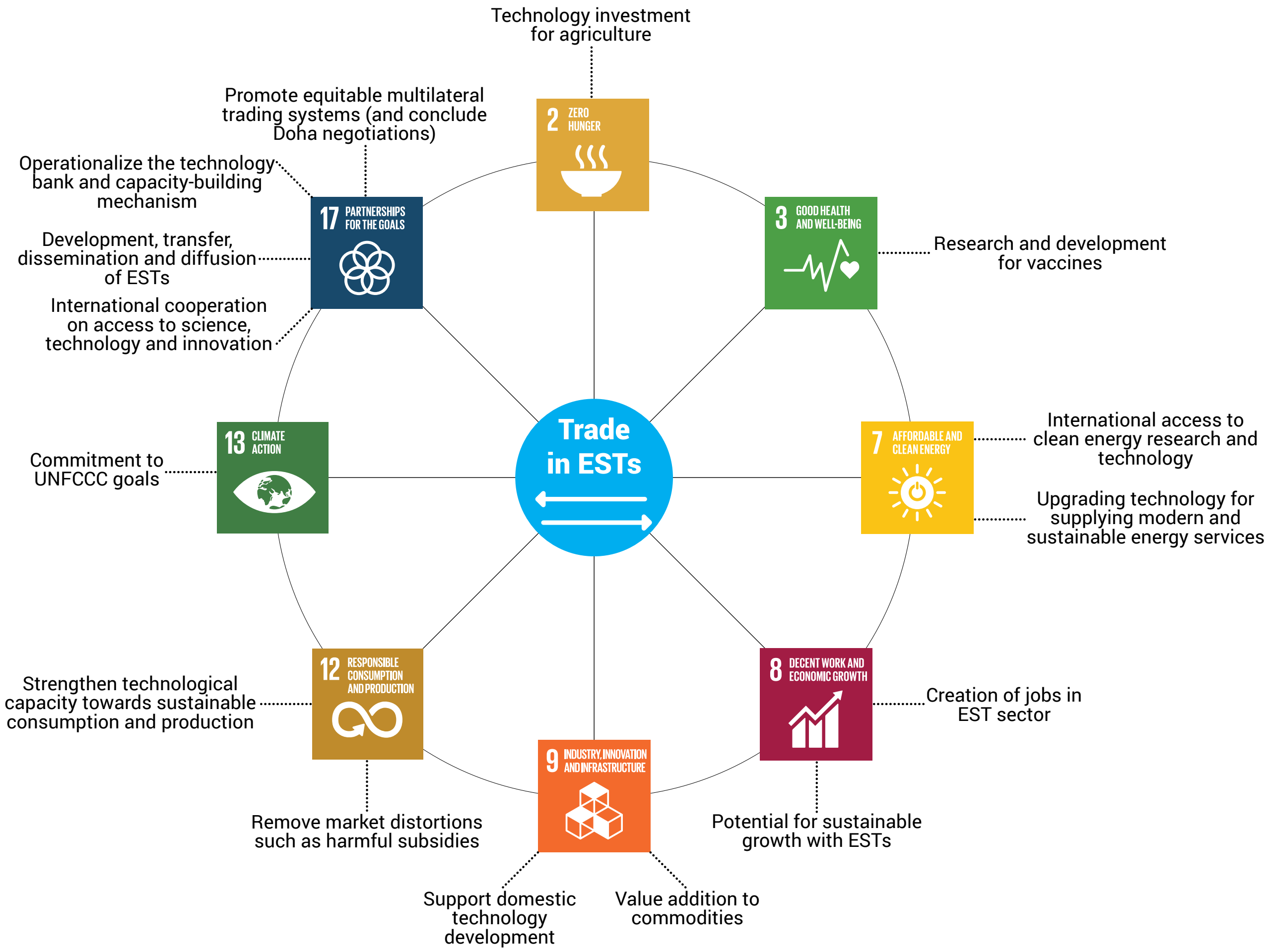
Global trade in ESTs has increased by over 60% from USD 0.9 trillion in 2006 to USD 1.4 trillion in 2016, with renewable energy technologies accounting for more than one third of the total trade value, followed by wastewater management and water treatment and solid and hazardous waste management technologies. While emerging economies such as China have dramatically increased their share in world trade of ESTs, many low-income countries, especially least developed countries (LDCs), have not yet fully benefited from EST trade.

About the study

This report aims to enhance understanding of the implications, capacity needs and enabling conditions for trade liberalization of ESTs, with focus on developing countries. It focuses its analysis on five ESTs, namely solar photovoltaic cells (PVs), water filters, waste incinerators, gas filtering machinery, hemp and flax fibers.

To do that, the study takes a holistic approach and combines trade flow analysis with policy research. It draws upon findings from two regional assessments on EST trade in the Association of Southeast Asian Nations (ASEAN) and the East African Community (EAC), including country case studies in Malaysia and Kenya. Data was collected from multiple sources, including the United Nations Comtrade database, the World Trade

Trade in ESTs and the Sustainable Development Goals



Organization (WTO) database on trade in services, country- and company-level data, as well as scientific publications.

While acknowledging that trade relationships linking countries, especially in the context of technologies, are growing increasingly complex and do not simply include goods and services but also other intangibles such as licensing, foreign direct investment and other forms for knowledge and technology exchange, the study focuses its analysis on goods and services due to data availability. Given the high complementarity between goods and services in ESTs and the importance of services trade for developing countries, the study tries to shed new light on trade in environmental services by analysing interlinkages in the sector and trade patterns. A special focus is also placed on the discussion of challenges and limitations to facilitate the discussion and progress in this matter.

Moreover, a comprehensive sustainability assessment framework is presented to illustrate the benefits from selected ESTs including solar PVs cells, water filters, waste incinerators, and filters for gases. This framework can be applied by countries aiming to assess their potential options in terms of engaging in EST trade.

Finally, by taking stock of trade negotiations related to ESTs and linking it with market trends and policy landscapes, the study offers insights into global trade governance and potential ways forward for developing countries to participate in related negotiations.

Key findings

Trade in ESTs[1] is increasing, with growing participation of developing countries

Despite a slight decline in trade flows since hitting a peak in 2011, world trade in EST related goods has generally been on an upward trend since 2006. However, the bulk of the EST industry is still concentrated in a relatively small number of countries. As for the larger group of ESTs, trade in selected ESTs is still dominated by developed countries and emerging economies. The main exporters of the selected ESTs between 2006 and 2016 were China, Germany, the United States (US), Japan and Korea. Among developing countries, the top traders were Mexico, Malaysia and South Africa. New Caledonia, Senegal, Uganda and Ethiopia are amongst LDCs that export the most. The most traded EST with a clear environmental end-use is solar photovoltaic modules, wafers and cells.

Growth rates of total EST trade have been volatile since the global financial crisis in 2009, especially for LDCs, and reached a peak in 2010. During the period 2006 to 2016, developing and BRIC countries' share in world trade of EST goods has been growing, approaching an overall trade surplus.

The analysis of trade in EST related services[2] reveals that the value of trade in this sector has more than quintupled over the last decade. Data from the top 61 companies that account for the largest share of trade by value in environmental consultancy and engineering services shows that revenues are largely concentrated in North America and Europe.

Negotiations aiming at liberalizing trade in ESTs have made progress at international and regional levels

Following early discussions in Asia-Pacific Economic Cooperation (APEC) and the WTO, recent efforts were made by a smaller group of countries to negotiate an Environmental Goods Agreement (EGA), with the aim of eliminating tariffs on selected environmental goods. From 2014 to 2016, intensive negotiations and discussions were carried out, resulting in a "landing zone" of 304 products with remaining divergences on about 15 products. However, a lack of agreement on the final list, among other things, finally led to a standstill on the negotiations.

In 2013, negotiations on the Trade in Services Agreement (TiSA) were launched. Several negotiating parties submitted proposals on further opening markets for environmental services and pushed for ambitious commitments. Yet, progress on reaching an agreement has since stalled.

Participation of developing countries in these plurilateral initiatives was limited, due to the lack of capacity, concerns over competitiveness of domestic industries, among other issues.

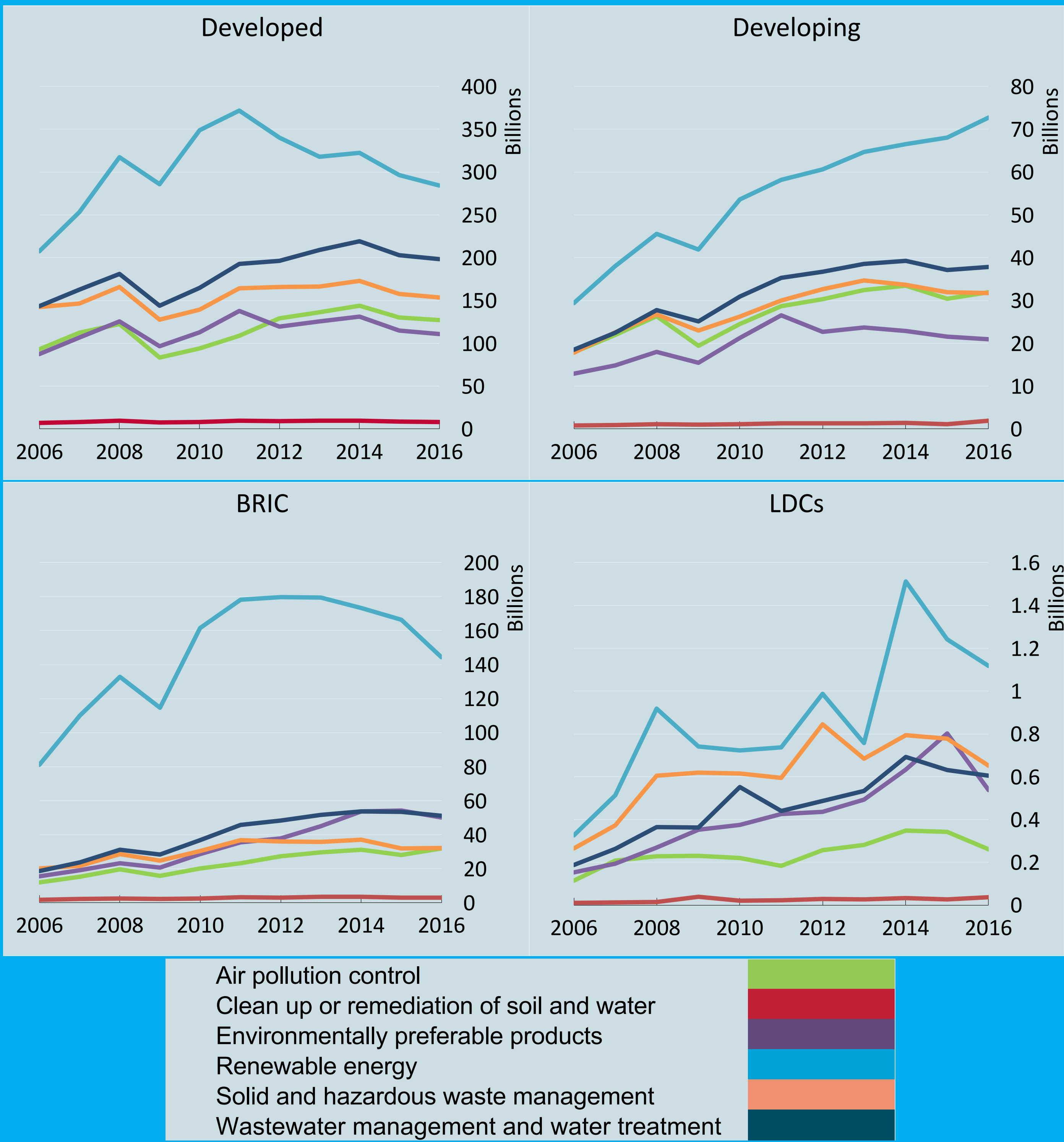
At the regional level, a noteworthy initiative is the APEC Agreement on Environmental Goods, which aims to voluntarily reduce applied tariffs on 54 product categories of environmental goods to no more than 5%. The agreement represents the most concrete trade liberalization commitments related to environmental goods among a large group of trading partners so far.

Footnotes

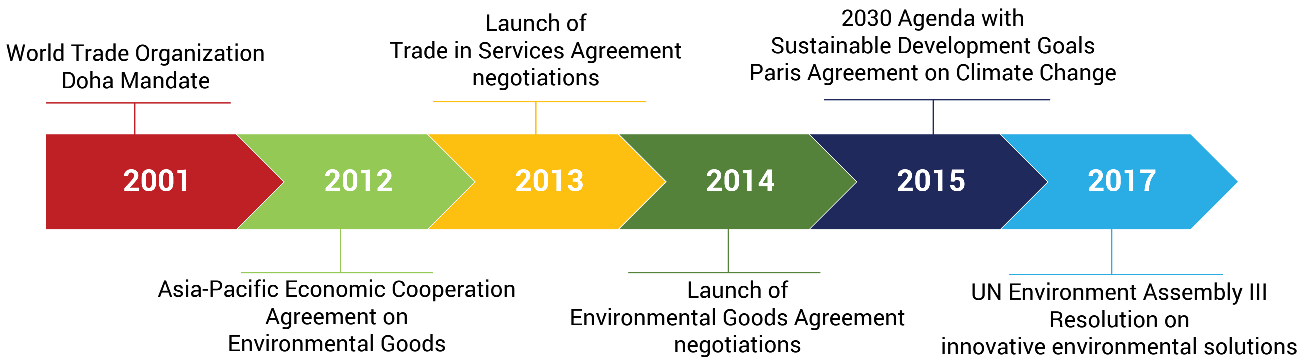
1. The trade flow analysis of goods related to ESTs is conducted for two sets of ESTs. The first set is a group of 144 products, selected based on existing lists of environmental goods, including the 'Friends of Environmental Goods' 153 List, and considerations of end-use and relevance to developing countries. The second set is a subset of the first group of products and contains 21 goods with a clearer environmental end-use and spare parts that are, while having multiple end-uses, highly relevant from a value chain perspective.

2. The lack of an agreement on classification and limited availability of data makes cross-country comparisons on trade in environmental services especially difficult. This report therefore analyses trade in select environmental services for a smaller sample of countries, for which data are available from the WTO and the UN COMTRADE databases.

Trade in selected ESTs: trends from 2006-2016



Key milestones on EST negotiations



Recent years witnessed a growing number of regional trade agreements (RTAs) with provisions related to ESTs, ranging from 'best-endeavour' provisions promoting overall environmental cooperation, investment and innovation, to specific lists for liberalization of environmental goods.

Developing countries enjoy great potential to benefit from EST trade and global value chains

Trade in ESTs offers great opportunities for developing countries in terms of economic growth, export diversification, technological development, and environmental protection. Environmental services in particular, provide opportunities for businesses in developing countries to integrate into global value chains, due to their localized nature. Trade in ESTs and the uptake of such technologies can further create sustainable jobs, especially in services related to the installation and maintenance of environmental products, systems and infrastructure.

The sustainability assessment provides a useful framework to comprehensively assess potential benefits of ESTs, including their contribution to SDGs and climate goals. This could be used to inform policy making related to EST trade and prepare for regional and international negotiations related to ESTs.

The assessment of five ESTs selected in this study shows potential benefits in a number of areas, such as energy access, health, pollution control, resource efficiency and employment.

Non-tariff measures and capacity limitations in particular pose a significant challenge to trade in ESTs.

While tariff rates have reduced substantively for many ESTs over past decades, further reductions, or indeed the elimination of tariffs, could help to reduce administrative costs for customs authorities and thereby facilitate smoother trade of ESTs.

Trade in ESTs is, however, impacted more by non-tariff measures, which include technical requirements, quality conditions and proofs, customs formalities and valuation practices, and restrictions on labor mobility WTO's Environmental Database reports 1176 notifications on environmental measures made by WTO Members in 2016 of which the majority relate to technical regulations or specifications (29.2%).

At the business level, a lack of information and knowledge about ESTs, limited capacity to explore opportunities in global markets, and difficulty accessing finance for trade in ESTs act as barriers to growth in EST trade. Furthermore, shortages of skilled labor to provide services related to the design, installation, and maintenance of ESTs can be a challenge.

A holistic approach based on sound data and statistics coupled with enabling measures at the national level, as well as improved coherence between trade and environmental policies could help developing countries further harness trade opportunities in ESTs

To further enable developing countries to fully harness the opportunities presented by trade in ESTs and increase their engagement in related trade negotiations, a holistic approach is needed, including data and research, awareness raising, capacity enhancement, and policy coherence at both national and global levels.

A better data system would need to ensure environmental credibility of defined ESTs, address the issue of dual-use, improve classification of environmental services, capture the complementarity between environmental goods and services, and promote standardization and harmonization of data collection.

Many developing countries, especially LDCs, have not been able to build effective domestic markets or sound productive capacity for ESTs. Therefore, at the country level, policy measures could be taken to promote and encourage trade and investment in EST sectors, build productive capacity via green industrial policy, improve the skills of the labor force, ensure coherence between environment and trade policies, and effectively assess impacts of EST trade based on in-depth sustainability assessments.

All measures should take country-specific factors such as environmental needs and priorities, as well as financial and technology-based needs into account to enable ESTs trade flows to have a meaningful impact for both exporting as well as importing countries. There is no one-size-fits-all approach that can be used by all countries to harness and maximize the opportunities of trade in ESTs.

Trade rules and negotiations can make big contributions to EST trade by providing a sound governance system.

At the global level, there are numerous factors that could help the trade governance system better facilitate EST trade. These include an integrated approach to goods and services in EST trade negotiations, more flexibility to accommodate concerns over sensitive products and industry competitiveness, and a practical approach to defining ESTs and harmonizing data. The definition should be based on environmental credibility, applicability, as well as the interests of both developed countries and developing countries.

Besides negotiating new provisions in areas such as trade remedies and subsidy disciplines, the current multilateral trading system also provides a number of options to promote ESTs, based on agreements and work programmes of various WTO committees and working groups. Some examples of such rules and policy instruments include Intellectual Property Rights (IPR), environmental labelling, standards, trade facilitation, government procurement, and trade finance.

The growing number of RTAs with environmental provisions provides another useful way to open trade and investment in ESTs. While outcomes at the multilateral level remain desirable and optimal, plurilateral initiatives, and especially RTAs, could serve as effective building blocks and templates for eventual liberalization outcomes at the multilateral level. Adopting a more flexible approach that takes the specific needs and sensitivities of both developed and developing countries into account while at the same time maintaining environmental credibility, seems to be critical for successfully negotiating trade liberalization for ESTs.

Next steps

Important questions remain for future research. First of all, more and better data could be collected to enable more in-depth analysis and informed policy-making, especially in the environmental service sector. This could include the assessment of trade flows at a more disaggregated level, as for example, taking into account the different destinations of exports from each country or country group. Furthermore, researchers should look to further explore the full picture of technology trade and transfer, including foreign direct investment and licensing, etc. Based on this knowledge, capacity building and policy dialogue should be promoted. Vital to such efforts are the collaboration and exchange across disciplines, sectors and borders.

1. Introduction

1.1 Trade in environmentally sound technologies and sustainable development

The Paris Agreement on Climate Change and the 2030 Agenda for Sustainable Development, both adopted by the international community in 2015, have opened a new chapter on global governance of environment, climate and trade. The 2030 Agenda and its Sustainable Development Goals (SDGs) are based on the understanding that the different dimensions of sustainable development, namely social, environmental and economic, are interlinked and can only be achieved through an integrated approach. Trade has been identified as a cross-cutting tool for implementation of the 2030 Agenda and its SDGs. Itis particularly important for Goal 17 on partnerships, but there are several other SDGs with explicit trade targets including SDG 2 on zero hunger, SDG 3 on good health and well-being, SDG 14 on life below water and many more (WTO, 2018).

Trade can drive sustainable development in several ways, including by facilitating a more economically and environmentally efficient allocation of resources and bridging relative differences in resource endowments across countries. If properly harnessed, the specialization, competition and innovation promoted by trade can drive down the costs of environmental goods and services and have positive effects on prosperity, jobs and equality. Furthermore, trade can facilitate the creation and expansion of markets for sustainable products and connect more businesses into global value chains (WTO and UNEP, 2018). Trade can thereby contribute to economic development and diversification that increases living standards and reduces environmental degradation.

While less developed countries often fear that increased competition through open markets will harm domestic industries, analysis by the Organisation for Economic Co-operation and Development (OECD) has shown that the export of intermediate goods that are then processed in another country and again exported, is even more productive than just exporting final products (OECD, 2016a).

Trade can further play a crucial role in the dissemination of ESTs. ESTs, often also referred to as “clean” technologies, are technologies that reduce environmental risk and minimize pollution as well as energy and resource use. Examples include technologies related to renewable energy, waste management and pollution management.

ESTs are essential in the fight against climate change and achieving the global goals. In terms of adaptation, technologies such as early warning systems can enable countries to build climate resilience and deal better with extreme weather events. The deployment of ESTs such as solar PV cells can further mitigate greenhouse gas emissions in energy supply. Besides SDG 7 on energy, clean technologies are also related to many other SDGs, including SDG 3 on health (reducing air pollution) and SDG 11 (resilient and sustainable solutions for cities). By providing access to and driving down the cost of such technologies, trade in EST offers triple-win opportunities for the economy, environment and society.

The importance of environmentally sound innovations and technologies and their diffusion was recently reiterated by the members of the United Nations Environment Assembly (UNEA), who adopted a Resolution on “Investing in innovative environmental solutions for accelerating the implementation of the Sustainable Development Goals” in December 2017. Countries have also already taken decisive steps at the national and regional level. Examples include ASEAN and the EAC, which are both regions that adopted supporting policies and regulatory frameworks. ASEAN produced the ASEAN Socio-Cultural Community Blueprint (2009-2015), which highlighted the use of ESTs to achieve sustainable development in the region, and the EAC developed the ECA Climate Change Master Plan (2011), which presents an enabling framework for private-sector investment in ESTs.

These positive developments are reflected in global market trends: global trade in ESTs has increased by over 60% from USD 0.9 trillion in 2006 to USD 1.4 trillion in 2016, with renewable energy technologies accounting for more than one third of the total trade value, followed by wastewater management and water treatment and solid and hazardous waste management technologies. Some studies estimate the sector to be much larger. A report by the German Ministry for the Environment estimates that the global market value for environmental technology and resource efficiency will increase from EUR 3.2 trillion in 2016 to nearly EUR 6 trillion in 2025, equivalent to average annual growth of 6.9% (BMU, 2018). The demand is and will continue to be driven in part by environmental and health regulations to address air, soil and water pollution, as well as regulations that aim to reduce GHG emissions by improving fuel efficiency, expanding renewable energy generation and cutting down on fossil-fuel imports.

Trade in ESTs comprising environmental goods as well as environmental services represents an opportunity for all countries, but developing countries in particular, to transition to a green economy more efficiently. Enabling freer global flows of ESTs by addressing tariff and non-tariff barriers to trade would lower the cost of access and consequently the cost of technology deployment and environmental compliance. Lowering the cost of access to technologies as well as intermediate goods across global supply chains would help generate economies of scale, produce new investment opportunities in the manufacturing and services industries, and create green jobs. However, trade-related measures aimed at market-opening would also need to be accompanied and complemented by adequate flanking policies targeted at sustainable consumption and production, such as environmental regulation and sustainability standards, to achieve maximum impact.

This would represent a very effective role that trade policy can play in facilitating a triple win in terms of environmental improvement, economic development and enhanced social indicators, such as reduced mortality rates, and the productivity benefits that a cleaner environment and lower pollution would make possible.[3] For example, according to the 2017 State of the Global Air Report co-published by the Health Effects Institute, air pollution, particularly fine particulate matter (less than or equal to 2.5 μm in aerodynamic diameter),[4] also known as PM2.5, was the leading environmental cause of death on the planet causing four million deaths worldwide. In China, which together with India accounted for 2.2 million of these deaths in 2015, PM 2.5 is primarily caused by coal burning followed by fossil-fuel powered transportation (IHME and HEI, 2017). Lowering the trade-related costs of access to ESTs like renewable energy equipment and components necessary to produce electric vehicles would be a step further in facilitating their deployment and addressing pollution related deaths.

Promoting trade in clean technologies is also essential for innovation. According to the Global Innovation Index 2018 published by the World Intellectual Property Organization (WIPO), beyond the actual invention of such technologies, the diffusion of technologies is one of the biggest challenges with respect to energy innovation. Often

Footnotes

3. Benefits are not listed in any hierarchical order given the complex inter-relationship between various outcomes for instance good health and economic productivity.

4. 1 μm = 10-6 m

the costs associated with the commercialization and uptake of such innovations are underestimated and incentives to tackle these issues are lacking. Thus governments have a central role to drive the transition by establishing the right incentives and regulations (Cornell University, INSEAD and WIPO, 2018).

While emerging economies such as China have remarkably increased their share in global EST trade, many low-income developing countries, especially LDCs, have not yet fully benefited from EST trade. Their limited participation in the global market for ESTs and associated trade negotiations is often due to a perceived lack of export opportunities, sensitivities regarding the competitiveness of domestic industries, and a lack of knowledge and capacity to assess potential opportunities and challenges.

This report aims to enhance global understanding on the implications, capacity needs and enabling conditions for trade liberalization in ESTs. The report provides an overview of the current patterns and trends in global trade in selected ESTs and analyzes the policy landscape, as well as highlights potential challenges and opportunities for developing countries. In doing so, the study aims to enable countries to develop a sound understanding of trade in ESTs and factors and considerations that need to be taken into account when designing and implementing related policies. The report further identifies existing gaps and areas where future work is needed.

1.2 Main concepts

ESTs are technologies that "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes" (Agenda 21). They are not just "individual technologies, but total systems which include know-how, procedures, goods and services, and equipment, as well as organisational and managerial procedures for promoting environmental sustainability" (UNCED, 1992).

Closely related to ESTs is the term of environmental goods and services, which has been more widely used in trade negotiations and discussions. There is no precise definition of environmental goods and services so far and some WTO members have attempted to resolve this by listing products of interest to them. These have generally fallen into six categories, namely air pollution control, renewable energy, waste management and water treatment, environmental technologies (i.e. emission reduction, heat and energy management, environmental monitoring equipment), carbon capture and storage, and other areas that may deal with disposal, natural resource protection, etc. (WTO, n.d.-a).

The remainder of this chapter provides a breakdown of ESTs into three main clusters: environmental goods, environmental services, and, as a subcategory of these two groups, environmentally preferable products (EPPs) and services.

1.2.1. Environmental goods

Environmental goods related to ESTs can be defined as tangible items that fall essentially in two major categories:

(1) Conventional environmental goods, including raw and manufactured items that are used to undertake environmental tasks. They include goods directly used to tackle or reduce pollution such as renewable and clean energy technologies, pollution management and monitoring equipment, and waste treatment systems.

(2) EPPs, industrial and consumer goods whose production, use and/or disposal produces less negative environmental effects relative to alternative products serving the same purpose (EPPs have been also defined by the United Nations Conference on Trade and Development (UNCTAD) as type-B). They include commodity-based goods and agricultural production standards such as organic, jute and textile-based products, forest-based non-timber products, certified aquaculture, goods made of natural-fibres, and

other natural resource-based outputs (UNESCWA, 2007). According to the OECD, EPPs should be identified based on the function the product performs by design, and/or its own environmental impact using life cycle analysis, and/or the environmental impact of other goods which the product could improve (Tothova, 2005; EC, 2016b).

Definitions and lists of environmental goods have been provided by the WTO, the OECD, APEC, the World Bank, and UNCTAD. Multilateral, plurilateral, regional and bilateral negotiations over the liberalization of EGS have taken place at the WTO and APEC and through other regional and bilateral trade initiatives, as described in Chapter 2. Table 1.1 provides an overview of lists developed by international organizations. While these lists often provide the basis of negotiations, new lists are usually negotiated in trade talks, as for example was the case for the EGA. This will be discussed in more detail in Chapter 2.

1.2.2. Environmental services

The UN Central Product Classification (CPC prov.) published by the Statistical Commission of the United Nations in 1991 contains seven subcategories of environmental services, including activities in relation to sewage, refuse disposal, sanitation, cleaning of exhaust gases, noise abatement, landscape protection, and other services for environmental protection. As presented in Chapter 2, the CPC prov. has been adopted as the model for the Services Sectoral Classification List (also called 'W/120') issued by the WTO Services Trade Council and further used in the 1995 General Agreement on Trade in Services (GATS). The W/120 list contains twelve categories, four of which are specific to environmental services: sewage services, refuse disposal services, sanitation, and other services including noise abatement, cleaning of exhaust gases, and generic protection services (Geloso Grosso, 2007).

In addition, the European Union (EU) provided a separate list as part of the GATS negotiations in which environmental services are classified as either "purely" environmental or services with an "environmental component", such as specific forms of transportation, construction, consulting and engineering, urban planning etc. (Bucher, H. et al., 2014). Along with these lists, the classification of environmental services by the OECD and the Statistical Office for the European Communities (EuroStat) was issued for purposes of harmonized data collection and, similar to the EU GATS list, it includes two macro categories (OECD, 2001):

i) services provided for environmental protection, pollution control, remediation or prevention activity – including monitoring and engineering services, environmental research, education, environmental consulting, accounting, and other matters;
ii) services provided for specific environmental media – such as wastewater and solid waste management, air pollution control, and noise abatement services.

Finally, the APEC recently published a tentative 'open' list for research and policy purposes that includes ten macro-categories and 883 environmental services-related technologies spanning activities in connection to pollution prevention and abatement, as well as environmentally preferable services.[5] The ten categories of services relate to: air pollution, wastewater treatment, solid and hazardous waste management, noise abatement, soil remediation, environmental monitoring and analysis, administration for nature risk, natural resource protection and conservation, environmentally preferable services, and services related to climate change mitigation in accordance with international conventions (Li et al., 2013).[6] Table 1.2 reports classifications issued specifically for environmental services.

Footnotes

5. As in the case of EPPs, environmentally preferable services are those services whose processing or outcome is less polluting than their conventional alternatives, such as eco-tourism, clean transportation, services linked to EPPs, etc.

6. The APEC list has not been endorsed by its members and it is not, as we speak, subject to any ongoing negotiation.

Table 1.1 Key milestones on EST negotiations

Source	Number of HS 6-digit product subheadings	Definition of environmental goods	Content
OECD (1995) Illustrative list developed for analytical purposes	164	Activities which produce goods and services to measure, prevent, limit, minimize or correct environment damage to water, air and soil as well as problems related to waste, noise and ecosystems. This includes cleaner technologies, products and services that reduce environmental risk and minimize pollution.	• Pollution management (air pollution control, wastewater and solid waste management, remediation and clean-up, noise and vibration abatement, environmental monitoring and assessment). • Cleaner technologies and products (resource efficient technologies, processes, and products). • Resources management group (indoor air pollution, water supply, recycled materials, renewable energy plant, energy saving and management, sustainable agriculture, forestry and fisheries, natural risk management, eco-tourism…).
UNCTAD (1995) UNCTAD extends the definition of environmental goods and services to the entire life cycle of a product. No official list has been presented, though the OECD published 22 codes to categorize different kinds of EPPs in the sectors of transport, energy, pollution control, life-cycle extension, waste and scrap, and other generic EPPs (Tothova, 2005).	22[7]	EPPs: Products which cause significantly less environmental harm at some stage of their life cycle (production, processing, consumption, [or] waste disposal) than alternative products that serve the same purpose, or products the production and sales of which contribute significantly to the preservation of the environment.	• Products which are more environmentally friendly than petroleum-based competitors. • Products which are produced in an environment-friendly way. • Products which contribute to the preservation of the environment.
World Bank (2007) The World Bank identified a set of 43 core environmental good categories relevant to climate change mitigation, which was proposed for accelerated liberalization. This list is a subset of the WTO list proposed by members comprising 153 product categories (HS 6-digit level).[8]	43	The definition follows the one provided by the WTO. Yet, the list focuses on a narrow-definition of ESTs as those end-goods and services treating a specific environmental problem (type-A).	The list was drawn from a broader list of 153 products proposed at the WTO as the 'Friends-list' that comprised categories, such as renewable energy products, solid waste management, and heat and energy management products. The list includes a wide variety of products such as solar collectors and system controllers, wind-turbine parts and components, stoves, grates and cookers and hydrogen fuel cells.

Table continues over page

Table 1.1 Key milestones on EST negotiations (continued)

WTO (2011) A compilation by the Chairman of the special session of the CTE collecting all submissions by member states in the Doha Round talks. During the negotiations, four main approaches emerged with countries unable to find an agreement (Balineau and De Melo, 2013; Wu, 2014). Finally, drawing on the so-called 'list approach', a compendium reference list was issued that brought together different country submissions. Nevertheless, widespread disagreement remains.	408	Activities which produce material, equipment or technology used to address environmental problems or products considered preferable to similar goods because of the relative benign impact on the environment.	• Type-A: Conventional environmental goods - Industrial goods used to provide environmental services to address pollution of water, soil and air. • Type-B: EPPs -Industrial and consumer goods that have environmentally preferable characteristics relative to substitute goods. (Only type-A have been considered so far)
APEC (2012) The list of 54 HS 6-digit product categories slated for voluntary tariff reduction to 5% by the APEC economies.	54	Industry sector devoted to solving, limiting or preventing environmental problems.	• Renewable and clean energy technologies. • Solid and hazardous waste, and waste treatment technologies. • Environmental monitoring and assessment equipment. • EPP (limited to one single HS subheading)

Source: Author's elaboration based on Bucher et al. (2014); Znamenackova et al. (2014); De Alwis (2015); Baltzer and Jensen (2015); World Bank (2007); APEC (2012); Sugathan (2013a).

Notes: The table does not include previous lists adopted by the same organizations (e.g. the APEC 1997 EVSL initiative with 104 HS-categories) or lists defined for research scopes (e.g. ICTSD mapping studies and several other adopted in academic articles such as Hufbauer and Kim (2010), Khatun (2012), Jha (2008, 2013)). HS- indicates the number of 6-digit subheadings informing each list.

Footnotes:

7. 22 is the number of categories identified by the OECD in 2005 for analytical purposes. No official list has been issued by UNCTAD (Tothova, 2005).

8. The list was proposed as a starting point for discussions over liberalization on climate-friendly EGs within the WTO by the US and the EU in 2007.

Table 1.2 List of environmental services

Source	Description	Categories[9]
UN (1991)	CPC prov. is used for scheduling purposes under the WTO, Government Procurement Agreement negotiation, member commitments and the Free Trade Agreement (FTA) negotiation. The system provides a framework for collection and international comparison of the various kinds of statistics. It includes seven categories of environmental services.	• Sewage services (CPC 9401) • Refuse disposal services (CPC 9402) • Sanitation services (CPC 9403) • Cleaning of exhaust gases (CPC 9404) • Noise abatement services (CPC 9405) • Nature and landscape protection services (CPC 9406) • Other environmental protection services (CPC 9409)
WTO W/120 (1995)	The services sectoral classification list (MTN.GNS/W/120) is provided by the WTO for the GATS negotiation and statistical use. It reflects a traditional view of environmental services as public infrastructures (i.e. services supplied to the community) and focuses mostly on end-of-pipe services for waste management and pollution control (it mostly does not cover design, research and development (R&D), engineering and consulting that upgrade operational end-of-pipe services). There are twelve categories/ sectors in the list, four of which refer to environmental services.	• Sewage services • Refuse disposal services • Sanitation and similar services • Other services (cleaning of exhaust gases, noise abatement, nature and landscape protection, other environmental protection services)
EU proposal (GATS)	The EU proposed a specific list under the GATS negotiations. This was meant to extend the coverage to environmental-related services, such as design, engineering, R&D and consulting services which remain classified elsewhere in GATS. The list includes two categories, 14 sub-categories further divided in 31 groups for a total of 47 specific services.	"Purely" environmental services: • Water for human use and wastewater management • Solid/hazardous waste management • Protection of ambient air and climate • Remediation and cleanup of soil and water • Noise and vibration abatement • Protection of biodiversity and landscape • Other environmental and ancillary services "Environmental-related" services: • Business services with environmental component • R&D with environmental component • Consulting, contracting and engineering with environmental component • Construction with environmental component • Distribution with environmental component • Transport with environmental component • Others with environmental component

Table continues over page

Table 1.2 List of environmental services (continued)

OECD/Eurostat (2001)	The manual identifies environmental services as those provided to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems. Compared to the W/120 list, it further specifies detailed examples of services under each category (and CPC) so as to capture both services that are unique in their environmental use and services with dual uses (these include design and engineering services, site investigation and surveying, R&D, services related to construction and installation, data monitoring and testing, distribution services, and training). The list includes two categories, twelve subcategories, and 38 specific services.	Services provided for one or more environmental protection, pollution control, remediation or prevention activity: • Design, consulting and engineering • Preparation of sites and construction, installation, repair and maintenance • Project management • Environmental R&D • Analytical services, data collection, testing, analysis and assessment • Remediation and cleanup of soil, surface water and groundwater • Eco-system and landscape protection services • Environmental education, training and information Services provided for specific environmental media: • Water and wastewater management (sewage services, water for human use) • Solid and hazardous waste management (refuse disposal, recycling, sanitation) • Air pollution control • Noise and vibration abatement
APEC (2013)	APEC negotiations do not involve services. Yet, in a recent report a comprehensive list of environmental services was drafted drawing on the previous APEC classification based on indoor, outdoor, and global environmental services. The current list includes ten categories, 65 subcategories, and 883 environmental service-related technologies (Li et al., 2013).	• Air pollution • Wastewater treatment • Solid and hazardous waste management • Noise abatement • Soil remediation • Environmental monitoring and analysis • Administration for nature risk • Natural resource protection and conservation • Environmentally preferable services • Services related to climate change mitigation in accordance with international conventions

Source: Author's elaboration based on Li et al. (2013) and OECD (2001).

Notes: Other lists have been drafted for research-related purposes (Kommers, 2014a; Sauvage and Timiliotis, 2017).

Footnotes:

9. Categorises further include several product specifications and sub-categories, which are not reported in Table 1.2.

1.3 Conceptual framework

With the emergence of global value chains, the trade relationships that link countries have become much more complex. In order to capture the features of trade in technologies and embedded intangibles and portray these relationships accurately and comprehensively, the framework of international trade requires thorough modification (Fu, 2018). For example, apart from import and export, technology is also exchanged indirectly through licensing and the provision of consultancy services, as well as through foreign direct investment. Therefore, unlocking trade opportunities in ESTs requires not only the liberalization of trade in environmental goods and services, but also access and an enabling environment for foreign investment to facilitate technology transfer.

In many cases, goods and services are so embedded within each other that it would be highly misleading to try to separate them. Many examples can be given, such as, R&D, technological knowledge, procedure design, or marketing services. Trade in goods related to ESTs (EST-EGs) and, in particular, services related to ESTs (EST-ESs), many of which are intangibles, has become an important source of value creation and income growth. In global value chains, the proportion of value created by intangible capital exceeds that of physical capital, a phenomenon that has been increasing in recent years. It is clear that the gains from trade will be systematically underestimated, especially as far as less industrialized countries are concerned. This is because such countries still have substantial sectors of production and consumption in intangibles that are routinely ignored in economic accounts. When resources used for unaccounted production are shifted to production for trade, wherein the product appears in economic accounts, the whole traded product will incorrectly be accounted as a 'gain from trade', whereas the actual gain is the traded product less the product it replaced. This tendency is also illustrated by the fact that the income share accruing to intangibles was 32% for the all products manufactured and sold worldwide in 2014, a figure almost double that of the share for tangibles in the same year (WIPO, 2017). No wonder, therefore, that some countries such as the United Kingdom (UK) have developed a strong and global business services sector, while others, such as the US, France, Germany, Japan or Italy have invested in building brands that enjoy international fame.

The world's resources and capabilities to create technology are clearly led by a few countries from the North, although the South has been catching up quickly. For example, South-South trade in green technologies is the fastest growing market segment. This explains why the diffusion of technology depends heavily on being traded. Trade in technology enables other countries and firms to use technological innovation in order to create jobs, national income, and societies that are more respectful of their natural environments. The EST case is no different; ESTs are also concentrated in a few countries. For example, according to WIPO (2017), patent-protected PV technologies are concentrated in China, the US, Germany, Japan, and the Republic of Korea most notably, and, to a lesser extent, in a few other European countries. Hence trade in ESTs has a crucial role to play in the diffusion of green technologies to countries in the rest of the world.

The flow of international trade in ESTs can be conceptualized as a flow of intangibles and physical goods between an upstream intangible-producing sector and a downstream intangible-using sector (Corrado et al., 2012). The upstream sector takes up freely available concepts, ideas or basic knowledge to produce "finished" ideas or commercial intangibles for downstream production in return for physical capital. Another way of thinking about these two interlinked sectors is in terms of an "innovation" sector and a "production" or "final output" sector. With such a depiction in mind, international trade can now be thought of as a fully integrated framework, which encompasses goods and embedded intangibles systemically. What makes this "conceptually new" trade model particularly difficult to map out is the fact that it is far more complex than the traditional trade in goods, both in terms of location and temporal configuration.

In light of the above, this report proposes to approach international trade in ESTs from the perspective of a global value chain framework, enabling the analysis of ESTs in terms of their composite characteristics. As already mentioned, ESTs comprise hardware (goods) and intangibles that are traded together in the form of licensing, services provision, and foreign direct investment. Due to data limitation, this report focuses on trade in environmental goods and some environmental services. Despite this limitation, the data presented in the study provides for an outline of a comprehensive framework and preliminary conclusions.

1.4. Methodology

This study takes a holistic approach that combines trade flow analysis with policy research. It also draws upon findings from two regional assessments of EST trade in ASEAN and the EAC, including country level case studies of Malaysia and Kenya.

It first takes stock of trade negotiations related to ESTs, with a focus on the participation of developing countries. This helps to provide an overview of past and ongoing international and regional discussions on trade in ESTs. It then maps out trade flows in selected ESTs that are most relevant to developing countries. The selection of these technologies is based on an extensive review of existing lists of environmental goods and services and relevant literature. Using the 'Friends of the Environmental goods' 153 List (2005) as a starting point, goods, technologies or products were added to the list (e.g. products relevant for developing countries) while those with unclear end-use (e.g. dual-use products) were excluded based on the criteria included in existing literature.[10]

Focused EST-EGs (see Annex 2) are classified based on the Harmonized System (HS) subheadings 17 (HS17). Depending on what categories are relevant to trade and global value chains, the study selected a few HS codes within each category. A major attribute considered was the ease with which their environmental end-use could be identified at the HS 6-digit level. In certain other cases, such as parts and components (e.g. ball-bearings for wind turbines), where it was more difficult to identify the end-use, it was decided to retain such products as they form an important part of the value chain.

These EST-EGs were then categorized into five groups:

1. air pollution control (APC),
2. wastewater management (WWM),
3. solid and hazardous waste management (SHWM),
4. renewable energy (RE),
5. and EPPs specifically relevant to developing countries.

The environmental goods analysed in this report are divided into two categories, one on the basis of the full list and the other on the basis of the selected list that focuses on environmental goods with clearer environmental end-use (see Annex 1). The trade flow analysis then maps out trade in these two categories of environmental goods, using UN Comtrade data. The mapping of trade in environmental services is much more challenging due to lack of data. Most of the data was obtained from UNCTADstat, UN Service Trade Database, WTO-World Bank I-TIP Services database and WTO's Environmental Database, complemented by firm-level data collected from the private sector.

Footnotes

10. Araya (2016); ASEAN SHINE (2016); ICTSD (2008); Jha (2008); Knudson, et al. (2015); UNEP (2014); WTO (2005)

The analyses of revealed comparative advantage (RCA) and intra-industry trade (IIT) are also used to examine a country's relative competitiveness in exporting the selected environmental goods as well as illustrate the composition of trade and industrial structure.

Given the high complementarity between goods and services in ESTs and the importance of services trade to developing countries, the study tries to shed new light on trade in environmental services by analysing interlinkages in the sector and trade patterns.

Based on the stocktaking of the trade negotiations and the trade flow analysis of the selected ESTs, the study further looks into opportunities and challenges for developing countries to harness trade in these ESTs. A comprehensive sustainability assessment framework is presented to illustrate multiple benefits from selected ESTs such as solar PV cells, water filters, waste incinerators, and filters for gases. This framework can be applied by countries aiming to assess their options while liberalizing EST trade.

Finally, the study offers insights into global trade governance and potential ways forward for developing countries to participate in related negotiations.

2. A brief history of trade negotiations related to environmentally sound technologies

This chapter will provide insights into the negotiating history for ESTs and outline some of the main issues and challenges faced by trade negotiators. While they are often supplied in a complementary or integrated manner, the market access conditions for environmental goods and environmental services are in most cases negotiated separately in different fora. The chapter thus will distinguish between these two tradeable components of ESTs and address the various negotiations that affect each.

2.1. Setting the stage: OECD and APEC lists

2.1.1. APEC Early Voluntary Sector Liberalisation Initiative

Trade negotiations on environmental goods as a specific category precede the WTO Doha
Trade negotiations on environmental goods as a specific category precede the WTO Doha
Round. The APEC was the first to single out environmental goods as a category for trade liberalization purposes as part of APEC's Early Voluntary Sector Liberalisation (EVSL) launched in 1997, similar to the Information Technology Initiative that was also launched the same year. The environmental goods EVSL was based on rapid liberalization of a set of products that would be individually nominated by APEC members and then arranged

according to an agreed classification system. As the aim of the APEC list was to obtain more favourable tariff treatment for environmental goods, APEC member economies limited themselves to specific goods that could be readily distinguished by customs agents and treated differently for tariff purposes. Thus, for instance, "like" products that were produced by an environmentally friendlier process or based on a life-cycle analysis were not addressed in the APEC EVSL list unlike in the OECD list, where such consideration of practicality could be relaxed (Sugathan, 2013a; Steenblik, 2005a).

It was intended that APEC would agree on frameworks for product coverage and phase-outs of tariffs before proposing them to the WTO. Environmental goods belonged to the sectors that enjoyed support for early liberalization by the time of the APEC leaders' meeting in Vancouver in 1997. However, there was a lack of impetus in liberalizing products given the voluntary nature of liberalization initiatives under APEC and the EVSL tariff cutting initiative lost momentum. A cautious approach among APEC economies has also been attributed to a reluctance to lower high levels of tariffs prevailing on certain products as well as due to the 'dual-use' (both environmental as well as non-environmental end-uses) of many products. In addition, broad sectors such as chemicals were excluded, given that they were already covered by other EVSL initiatives. Some overlap however did exist for certain products that were also covered by EVSL initiatives for medical equipment and instruments and energy (Steenblik, 2005b).

A combined proposal including all EVSL lists and a comprehensive package including undertakings on four elements, namely (i) tariffs, (ii) services, (iii) non-tariff measures and (iii) economic and technical cooperation, was presented to trade ministers and APEC leaders at their annual meeting in Kuala Lumpur in November 1998. Following a lack of agreement to move forward on tariffs, the ministers agreed to forward a consolidated list of environmental goods and refer tariff elements of the EVSL proposals to the WTO for possible adoption by the WTO membership on a binding basis at the third WTO Ministerial Conference in Seattle in December 1999. A timetable was also proposed for tariff elimination with tariffs for specified products, in principle, to be completely eliminated by 2003 with some exemptions for sensitive products until 2005 (2007 for developing countries). But the complicated nature of the Seattle conference meant that little progress was made on the package. The initiative did however give rise to a consolidated list of products that APEC members nominated individually.[11] The list refers to the definition of the environment industry that was developed for analytical purposes by the OECD and Eurostat. The industry, according to the OECD and Eurostat, comprises "activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems." (Steenblik, 2005b)

2.1.2. The OECD List

The development of a list of environmental goods by the OECD was intended for research and analytical purposes and in order to illustrate the scope of the 'environment industry', not for negotiating purposes, although the OECD's Joint Working Party on Trade and Environment was also interested in developing a framework for future trade liberalization efforts. An informal working group on the environmental industry was set up by the OECD in collaboration with Eurostat and comprised of experts from OECD countries responsible for collecting and analysing data on environmental goods and services as part of their work at national ministries, national statistical offices and public or private research institutes (Steenblik, 2005b). The OECD/Eurostat Informal Working Group, after considering a number of alternatives, agreed on an interim definition of and classification system for the environment industry at its first meeting in Luxembourg in April 1995 as follows:

Footnotes

11. See Table A.2 in Steenblik (2005) pp19-23 for the full APEC list of nominated products.

"The environmental goods and services industry consist of activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use."

The Working Group added that for "For cleaner technologies, products and services, despite their importance, there is currently no agreed methodology which allows their contribution to be measured in a satisfactory way." (OECD and Eurostat, 1999, p. 10). For this reason, products defined in terms of their energy efficiency, for example, were not included in the original OECD list. Box 1 provides further details.

Box 1: Comparing the OECD and APEC list of environmental goods

The OECD list of environmental goods is purely illustrative (not exhaustive) and is based on the definition of the environment industry highlighted above. This list was developed for analytical purposes and not trade negotiations (unlike the APEC's EVSL list). Unlike individual product nominations, which was the starting basis for the APEC list, the OECD list was created deductively. It started from general categories based on the Environment Industry Manual created by the OECD and Eurostat for national statisticians to assist them in measuring their national environmental industries. Under the categories in the manual, environmental goods and services were categorized under three broad headings: pollution management, cleaner technologies and products, and resource management. On the basis of these general categories of goods and services, the OECD Joint Working Party on Trade and Environment added examples of specific goods. The OECD list was broader in scope because there were no policy implications from the exercise unlike in the case of the APEC initiative.

A detailed comparison of the APEC EVSL as well as OECD lists have been provided by Steenblik (2005).

According to Steenblik, there is only a 30% overlap between the products in the OECD and APEC lists. That is attributed to various reasons, as for example a difference in terms of categories emphasized. For instance, under the category "Heat/energy savings and management", the OECD list specifies 14 tariff lines and the APEC list only three. The OECD list contains five tariff lines each under the sub-categories "hazardous waste storage and treatment equipment" and "waste collection equipment", whereas the APEC list contains none. The APEC list in turn contains more goods in the "environmental monitoring analysis and assessment" list than the OECD list, including products such as electricity and gas meters. Another reason was the inclusion of certain products such as 'chlorine' in a separate APEC EVSL initiative for chemicals, which resulted in them not being included in the environmental goods list. In other cases, the OECD list did not go into a greater degree of specificity for certain product categories as the APEC list did. In case they had done so, the degree of overlap would have been greater.

Given the illustrative nature of the OECD list, not all environmental goods were covered. Some of those that were included did not have specific HS commodity codes. In other cases, HS commodity codes also included goods which would not be considered as environmental goods. Further, the OECD list also did not make an attempt to go much more in detail beyond 6-digit (subheading) HS codes to identify only those goods that could be considered "environmental." In contrast, the APEC list was produced by a "bottom-up" process and includes "ex-headings" or nationally defined tariff lines that are more specific.

Both the OECD as well as APEC lists were taken into consideration for subsequent negotiations to liberalize environmental goods under the WTO but were not regarded as definitive.

2.2. Multilateral trade negotiations: talks under the WTO Doha Round

Multilateral negotiations on environmental goods and services in the WTO were launched in 2001 under Paragraph 31 (iii) of the Doha Ministerial Declaration, which calls for the "the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services". The mandate did not define the scope of environmental goods and services negotiations or set any deadlines other than the overall deadline for the Doha Round. Negotiations on environmental goods effectively took place in the special sessions of the Committee on Trade and Environment (CTE), although the final modalities of liberalizing environmental goods were to be dealt with by the WTO's Negotiating Group on Non-Agricultural Market Access that also dealt with other industrial goods. Negotiations on environmental services were handled separately by services trade negotiators in the special session for the Council on Trade in Services.

2.2.1. Environmental goods

The lack of clarity in terms of definition and scope of environmental goods led to two broad questions that underlay the challenge facing trade negotiators, namely (i) *what to liberalize and (ii) how to liberalize*.

The question of what to liberalize generated debate among members on whether to consider only goods that had purely environmental end-uses (so-called 'single end-use' goods), or also include goods that had both environmental and non-environmental end-uses ('multiple end-use' goods such as pipes). In addition, there was also the issue of whether to include agricultural products (such as biofuels and organic agricultural products). In cases such as organic agricultural products, the environmental benefit might arise not from the actual use of the product but in the process of producing it (using less or no chemicals or fertilizers). In other cases, the environmental benefit might arise at the use-stage (such as in the case of wastewater treatment equipment or electric vehicles) or at the disposal stage (biodegradable materials such as jute matting).

While some countries like New Zealand and Canada pointed out the importance of many 'dual' and 'multiple-use' goods in enabling important environmental outcomes, many developing countries as for example South Africa wanted to exclude such goods from the scope of liberalization and only liberalize those goods that served a single environmental end-use, even though this would enable only a handful of products to be included, with trade benefits being restricted to very few developing country members. Certain WTO members - both developing and developed - were also open to including "predominantly environmental goods", although the threshold for 'predominantly' was not defined (Claro et al, 2007). On the issue of 'how to liberalize' or the modalities of trade liberalization, members broadly adopted two types of approaches, namely (a) the list approach and (b) the project or integrated approaches.

List approach

Under the list approach a number of countries, mostly OECD WTO members, proposed lists of goods using the OECD and APEC lists as a starting basis. The idea was to permanently reduce 'bound tariffs'[12] on a final list of goods agreed upon as a result of negotiations. A consolidated set of products submitted by various WTO members was compiled by the WTO Secretariat[13] and exceeded 400 products. Following feedback from WTO members, on 27 April 2007, Canada, the EU, Japan, the Republic of Korea,

Footnotes

12 Bound tariffs represent the ceiling levels up to which a country is permitted to raise tariffs under WTO rules. More commonly exporters face 'applied' tariffs implemented by customs officials at the border which may be significantly lower than the bound rates. Once bound, rates are lowered through trade negotiations, while they cannot usually be raised again without the violating country incurring compensatory penalties under WTO rules.
13 WTO Secretariat, Synthesis of Submissions on Environmental Goods, TN/TE/W/63.

New Zealand, Norway, Chinese Taipei, Switzerland and the US (termed "Friends of Environmental Goods") submitted a joint proposal, JOB (07)/54, containing a revised list of environmental goods under 153 HS 6-digit subheadings which was termed as a "Potential Convergence Set" of products.

Many of the products submitted by the 'Friends' could be deemed to be relevant to addressing environmental problems such as air, water and land-based pollution as well as climate change. Moreover, their relevance to a number of multilateral environmental agreements such as the Kyoto Protocol and the Millennium Development Goals was highlighted in addition to their relevance for the delivery of environmental services (which are often traded in conjunction with environmental goods). However, this list did not adequately address the concerns of many developing country members of the WTO who were concerned about 'dual-use' of many, if not most, of the goods submitted under the list approach, even though it was contended that such goods could be critical to the delivery of environmental benefits and also hold out export-led opportunities for developing countries. Some developing countries also wanted to exclude sensitive items from the scope of negotiations or to apply longer tariff phase-out periods or less deep cuts in tariffs.

Brazil was concerned that most lists submitted focused on high-technology and industrial products to the detriment of lower-technology and agricultural products and called for the inclusion of ethanol. According to Brazil, any definition of environmental goods had to promote a triple win situation, namely that of trade promotion, environmental improvement and poverty alleviation. In this regard, there was also a call for lowering tariffs on environmental goods of export interest to developing countries.[14] The literature however is divided as to the overall efficiency of production and international trade in ethanol.

Other countries such as Kenya proposed the inclusion of agriculture or natural resource-based products that fall into the broader category of EPPs.[15] This however also raised the dilemma of using only process and production methods (PPMs) as criteria, which many countries - developing as well as developed - wanted to avoid. Nonetheless, EPPs that were not based on PPMs were also proposed by some members. New Zealand for instance included products based on end-use or disposal characteristics such as organic fertilizers, soaps made from natural oils and jute bags. The US included seven EPPs in a list of 152 potential EPPs that were identified by UNCTAD.[16] These included sisal and other textile fibres from raw agave, yarn of vegetable textile fibres, jute sacks and bags as well as twines, ropes and cables made of sisal and similar fibres. Some EPPs that were not defined on PPM terms such as for example bicycles, parts of electric locomotives and energy-efficient appliances included under the 'high environmental performance'/'low-environmental' impact category have also raised sensitivities among some WTO members.[17]

In addition to the issue of goods coverage, some WTO members also contended that the list approach did not adequately address non-tariff measures and issues relating to transfer of technology.[18] Two tracks of views emerged as a result of discussions

Footnotes

13. WTO Secretariat, Synthesis of Submissions on Environmental Goods, TN/TE/W/63.

14. See for instance proposals by Brazil (TN/TE/W/59) and Cuba (TN/TE/W/69).

15. Negotiating Group on Market Access - Market Access for Non-Agricultural Products, Joint statement by Ghana, Kenya, Madagascar, Mauritius, Nigeria, Rwanda, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe on Draft Elements of Modalities for Negotiations on Market Access for Non-Agricultural Products, TN/MA/W/40,11 August 2003.

16. Committee on Trade and Environment - Special Session - Communication under Paragraph 31 (III) of the Doha Ministerial Declaration - Non-Paper by Canada, the European Communities, Japan, Republic of Korea, New Zealand, Norway, the Separate Customs Territory of Taiwan, Penghu, Kinmen and Matsu, Switzerland, and the United States, JOB (09/132), 9 October 2009.

17. See for example submissions by the EU, TN/TE/W/56), Switzerland (TN/TE/W/57) and Japan (TN/MA/W/15).

in the Doha Round of negotiations. One track viewed technology transfer as naturally flowing not only through trade in ESTs but also aid and private investment, technical assistance, partnership between research organizations and small companies. This view for instance is reflected in a submission by Canada.[19] A different view was taken by some of the developing country members, who advocated for a differentiated approach such as transfer of environmental technologies on favourable and preferential terms to developing countries together with the necessary know-how and training for them on a non-discriminatory basis[20] and ability to set technology-transfer criteria for specific environmental projects that would enjoy unhindered access to environmental goods and services imports through a project based approach.[21]

Project-based and integrated approaches

Concerns with the list approach to liberalization of environmental goods led India, followed by Argentina, to advocate a 'project-based' approach, whereby specific environmental goods as well as services deemed important for a 'designated national authority' approved project would be liberalized for a specific time-bound duration. The approach was intended to respond to development-related 'policy-space' concerns and sensitivities associated with permanent liberalization of many environmental goods. These also included concerns of addressing environmental goods and services and tariffs and non-tariff measures in an integrated manner in addition to being responsive to technology transfer concerns. The projects were to be approved by criteria agreed upon multilaterally by WTO CTE members. Developed countries would also offer a 100% tariff concession to developing country exports whereas developing countries would offer a preference margin. Active cooperation was expected among members to promote technology transfer related to the specific environmental activities and to build capacity in developing countries. It was also provided that the WTO Secretariat would monitor such cooperation on the basis of members' notifications and reports on the technology transferred.[22]

However, the project approach did not find favour with other WTO members, given that the approach would not lead to permanent or binding liberalization. The approach was also regarded by some WTO members as complex and cumbersome to manage and inconsistent with WTO rules on non-discrimination.

Attempts were also made to reconcile both approaches. An informal non-paper presented by Colombia proposed liberalization of identified environmental 'single end-use' goods based on a list approach while goods with multiple-uses would only be liberalized if they were used in a project, programme, plan or system deemed to have verifiable environmental benefits by a designated national authority.[23]

In March 2011, Australia, Colombia, Norway, Hong Kong and Singapore proposed a list of 26 products drawn from the WTO 'combined' list of 411 products — the union of the six different lists submitted by developed countries (plus Philippines) as a starting point for discussions towards a "credible core-list" of environmental goods (Balineau and De Melo, 2011). However, the proposal was not extensively discussed or assessed by WTO members (Dupuy and Viñuales, 2013).

Footnotes

18. See for example Submission from China, (TN/TE/W/42).

19. Submission by Canada, TN/TE/W/50/Rev1.

20. Submission by Cuba (TN/TE/W/69).

21. Submission by India (TN/TE/W/51, TN/TE/54, TN/TE/60 and TN/TE/W/6).

22. Submission by India (TN/TE/W/51, TN/TE/54, TN/TE/60 and TN/TE/W/6); Submission by Argentina (TN/TE/W/62), Joint informal submission by India and Argentina (JOB (07/77).

23. Informal submission by Colombia, (JOB (06)149.

Despite attempts to bridge differences and reach an agreement, multilateral trade negotiations on environmental goods soon stalled and were also affected by the overall lack of progress in other areas of the WTO's Doha Round of negotiations.

2.2.2. Environmental services

Trade negotiations on environmental services have preceded the Doha mandate as they were part of the 'built-in' agenda of services liberalization agreed during the Uruguay Round of trade negotiations that also led to the establishment of the WTO in 1995. While the mandate of Paragraph 31 (iii) of the Doha Ministerial Declaration referred to both environmental goods and services liberalization, actual negotiations on environmental services were carried out separately from those for goods in the special sessions of the Council on Trade in Services. All four modes of services delivery were covered, namely:

- **Mode 1:** Cross-border trade in services (for e.g. the provision of environmental consulting services through the internet),
- **Mode 2:** The movement of consumers abroad to consume a service in the country of origin (e.g. environmental services industry professionals attending a paid training or university programme abroad),
- **Mode 3:** Commercial presence involving the establishment of a foreign environmental service provider in the host country (e.g. a German or French wastewater treatment company establishing a subsidiary in China to deliver services) and
- **Mode 4:** Temporary movement of natural persons abroad to deliver a service in the host country (e.g. temporary movement of Indian professionals to install air-pollution control equipment in a factory in Bangladesh).

While WTO members aimed for ambitious commitments across all modes of delivery in environmental services, certain issues and fault-lines emerged, which complicated a speedy progress in the conclusion of the negotiations.

Classification issues

The WTO classification of environmental services (1999) emerged during the Uruguay Round of trade negotiations and is based on the UN CPC prov. The CPC prov has been adopted as the model for the Services Sectoral Classification List (also called 'W/120') issued by the WTO Services Trade Council and further used in the 1995 GATS. The W/120 list contains 12 categories, four of which are specific to environmental services: (i) sewerage services, (ii) refuse disposal services, (iii) sanitation and similar services and (iv) other (cleaning services for exhaust gases, noise abatement services, nature and landscape protection, and other environment services not elsewhere classified) (Geloso Grosso, 2007). However, it was considered as too narrowly defined and not reflective of changes in the environmental industry, which was developing beyond traditional end-of-pipe/pollution control/remediation/cleanup towards integrated pollution prevention and control, cleaner technologies and resources and risk management. While no revised classification was agreed upon, WTO members were free to use their own classifications as long as the mutually exclusive character (no overlaps in terms of sectors) of the W/120 list was preserved.

The EU, for example, proposed a classification system which comprised 'core' services that could be classified as 'purely' environmental and correspond to environmental media (such as air, water, solid and hazardous waste, noise etc.) in addition to a 'cluster' of services such as design, engineering, R&D and consulting with an environmental end-use (Bucher et al, 2014). Colombia, a developing country, also proposed the inclusion of three additional services: (i) the implementation and auditing of environmental management systems, (ii) the evaluation and mitigation of environmental impact, and (iii) advice in the design and implementation of clean technologies. There was apprehension among some, mostly developing country members with regard to making unintended commitments in a number of other sectors while pursuing liberalization under a 'cluster' approach. There were also differences of opinion expressed as to where liberalization commitments in environmental consulting services should be scheduled, i.e. environmental services or consulting services.

Based on the EU classification proposal, Geloso Grosso (2007) also draws a distinction between "infrastructural environmental services", which would include services such as water for human use and sewage management and management of solid hazardous waste, and "non-infrastructure environmental services and support services", which would include services such as environmental and climate protection, remediation and cleanup of soil and water; noise and vibration abatement; biodiversity and landscape protection and other related environmental services.

Public nature of environmental services

Another factor that slowed down liberalization commitments in environmental services as compared to other services segments such as telecommunications was that many environmental services, such as solid waste management and wastewater treatment, were delivered by public utilities in many countries. WTO commitments regarding non-discrimination would apply only if such services were not supplied under 'government authority' and that too on a 'non-commercial basis' or in 'competition with other suppliers.' Given the important role that domestic regulation such as immigration policies or education requirements play in conditioning market access on services, there were also concerns expressed by developing countries about the implications of liberalization in these sectors on 'regulatory policy space' as well as affordability for poorer segments of the population in developing countries.

Identifying environmental services of export interest to developing countries

From an exporting perspective, comparative advantages with regard to infrastructural environmental services also lie mainly with OECD countries, which is also reflected in their role as 'demandeurs' for environmental services.

Developing countries further raised issues about technology and know-how transfer and the creation of domestic capacities. Cuba for instance proposed that market access negotiations should provide appropriate guarantees with respect to: (i) a real transfer of technologies on a favourable commercial basis to ensure that developing countries can enhance competitiveness; (ii) a transfer of associated know-how; (iii) the creation of national technical capacities, both human and institutional, to promote subsequent national development of these services; and (iv) specific commitments concerning modes of supply of interest to developing countries. To that end, it also proposed measures of special and differential treatment such as commercial credits with "soft" conditions and long grace periods, as well as preferential conditions when developing countries export "mode 4" environmental services (UNCTAD, 2003).

During the course of negotiations, WTO members followed a 'request-offer' approach in the negotiations, whereby they received requests by one or a group of members to make specific commitments and responded through suitable 'offers', reflecting what kind of commitments they were prepared to offer. Following the Hong Kong Ministerial Declaration of December 2005, a group of WTO members sent a collective request seeking commitments across all environmental services subsectors, namely sewage, refuse disposal, sanitation, cleaning of exhaust gases, noise abatement, nature and landscape protection, and other environmental protection services. However, water for human use (i.e. the collection, purification and distribution of natural water) was excluded as it formerly proved controversial among many developed and developing countries and civil society groups (Claro et al., 2007). The request also clarified that liberalization in these sectors would not "…impair the ability of governments to impose performance and quality controls on environmental services and to otherwise ensure that service suppliers are fully qualified and carry out their tasks in an environmentally sound manner." It reiterated that each WTO member could establish, maintain, and enforce its own levels of protection, inter alia, for consumers, health, safety, and the environment. It also recognized the important interplay between the liberalization of environmental services and the liberalization of other related services, such as construction, engineering, technical testing and analysis, and management consulting.

2.2.3. Overall assessment of the WTO Doha Round negotiations on environmental goods and services

Despite the promising opportunity for addressing global barriers to trade in environmental goods and services, talks under the Doha Round in general stalled given the overall challenge of reaching an agreement on a number of other negotiating mandates. Further, specific challenges relating to definitions and classifications as well as sensitivities regarding the impact on domestic manufacturing and services sectors hampered progress. There was also a lack of perceived export opportunities, which contributed to the lack of proactive engagement among many developing countries. In addition, issues such as non-tariff measures and questions of dealing with technological change and technology transfer were also not addressed, although certain proposals on addressing non-tariff measures on all industrial goods were made in the context of WTO Non-Agricultural Market Access negotiations.

An overall mercantilist approach with an emphasis on exports and market access as compared to recognizing the environmental and economic benefits of importing environmental goods and services may also have contributed to the lack of a positive outcome. WTO members subsequently prioritized specific areas such as trade facilitation, that were more amenable to a successful outcome. As a result, environmental goods and services did not form part of the so-called "Bali Package" agreed upon at the WTO's Bali Ministerial Conference in December 2013, although there was a pledge in the Ministerial Declaration to 're-invigorate' the rest of the Doha Round negotiations (ICTSD, 2013; WTO, 2013). At the same time, there was also a shift in focus from multilateral to bilateral, regional and plurilateral trade negotiations, which appeared more amenable to successful agreements on environmental goods and services.

2.3. Plurilateral negotiations on the Environmental Goods Agreement

Plurilateral negotiations for an EGA were launched on 8 July 2014 by 18 participants[24] representing 46 WTO members (including EU member states) (WTO, n.d.-b). These include 12 of the 15 largest world economies accounting for over 85% of the total trade in environmental goods and services (Baltzer and Jensen, 2015; Balineau and De Melo, 2013; De Alwis, 2015). While the APEC 54 list of environmental goods was used as a starting basis or 'reference point', there were several rounds of negotiations with 650 tariff subheadings being nominated initially, which was revised downwards to 304 tariff subheadings by the end of 2016.

The agreement was to become operational once a 'critical mass' of members in terms of a certain share of trade in the agreed upon goods had been reached. While this threshold has not been defined yet, it is generally understood to be about 90% of world trade in those goods. Once operationalized it would be an open plurilateral agreement, where the benefits of the agreement are to be extended on an most favoured nation (MFN) basis to all WTO members. However, during the course of negotiations, concerns were expressed about the possibility of free-riding by non-participants to the agreement. Further, while the aim was duty-free treatment of the proposed goods, the possibility of staging tariff reductions was also discussed, following concerns expressed by China as well as the EU on fully liberalizing certain sensitive goods (European Parliament, 2018).

While applied tariffs on more than half of the goods in the APEC 54 list are duty-free among the EGA participants, there could be value in removing even low levels of tariffs (the so-called 'nuisance tariffs'), which could lead to a reduction of implementation costs at the border (Sugathan, 2014). While the EGA's focus was on tariffs, there is an intention to create a "living agreement", in order to allow the addition of new products in the future and to address non-tariff barriers and services linked to environmental goods (EC, 2016a).

Negotiations were carried out in small groups where members worked through the proposed list and raised concerns about the inclusion of specific products. By October 2016, a "landing zone" had been identified for 304 products, despite persisting divergences on roughly 15 products including bicycles, wood products and gas-turbines. A lack of agreement on the final coverage of the list, as well as on a draft agreement text, resulted in the failure to successfully conclude the EGA by the end of 2016 (ICTSD, 2016). Key points of contention included the timing of phasing out tariffs and what constitutes a "critical mass" threshold of the share of trade in goods. Talks have so far not resumed since then, although several EGA participants have called for their revival in subsequent meetings of the WTO CTE.

Participation of developing countries in the EGA negotiations was limited only to China and Costa Rica. Some of the major concerns among the non-participating developing countries were; challenges with regard to defining environmental goods; the risk of making unintended commitments; a lack of perceived export interest; the prevalence of many sensitive industrial items with higher applied tariffs amongst the basket of APEC environmental goods; and a perception that since the market access gains from any EGA outcome would automatically flow even to non-participating countries, there was no need to engage in negotiations and make the required concessions. From an import perspective, it was also contended that countries could already lower applied tariffs autonomously on environmental goods if they felt the need to do so, even without making binding concessions through negotiations. These factors may partly explain concerns among EGA members such as China about 'free-riding',

It is clear that in order to secure greater participation and engagement of developing countries in any future phase of the EGA, there would need to be an identification of clear benefits as part of a trade package arising from such engagement that possibly also goes beyond simple market-access related concessions. While the complete list of 304 products, including the 15 sensitive ones, is not yet in the public domain, the EU has provided examples of some of the products nominated by category, as listed in Table 2.1.

The initial list of 650 products nominated by participants for EGA negotiations has also been published by Transport and Environment, a Brussels-based non-governmental organization. Transport and Environment has analysed this list and highlighted products with positive as well as negative environmental effects. They also proposed that EGA negotiators agree on a clear definition beforehand and that an impartial set of criteria, an impact assessment and a life cycle analysis be developed to understand the full impact of each good under consideration (Transport and Environment, 2015).

In this regard, the EU has already conducted a sustainability impact assessment on the EGA and published its final report in March 2016. The assessment found that the conclusion of the EGA between the current group of 17 negotiating parties (as of March 2016) could lead to an increase in trade, a reduction in the price of environmental goods and a reduction of carbon dioxide (CO2) emissions. In terms of trade flows, there was a projected increase in the value of trade up to EUR 21 billion with small and medium-sized enterprises (SMEs) particularly benefiting from a reduction in NTBs. There would also be significant benefits to developing countries in joining an EGA and reducing tariff and non-tariff barriers, such as an increase in imports and inward investment, resulting in improved access to environmental technologies and improved environmental protection as well as local job creation. Renewable energy projects could furthermore improve access to energy in rural areas with positive impacts on people's right to work, leisure,

Footnotes

24. Participants include Australia, Canada, China, Costa Rica, European Union, Hong Kong, Iceland, Israel, Japan, Republic of Korea, New Zealand, Norway, Singapore, Switzerland, Liechtenstein, Chinese Taipei, Turkey and United States

Table 2.1: Examples of products nominated by the EU during the EGA negotiations[25]

Insulating wool and panel boards	Energy saving
Insulating units of glass	Energy saving
Insulating panel boards	Energy saving
Wind-turbine components such as bearings or gearboxes	Renewable energy
Biodegradable erosion control matting	Environmental cleanup and prevention of damage
Oil skimmers	Environmental cleanup and prevention of damage
Equipment for litter collection from the water surface	Waste management
Biomass boilers	Waste management
Small Hydraulic turbines	Cleaner and renewable energy
Enzymes	Resource efficiency
Micro-organisms for water treatment	Water treatment and wastewater management
Pipes and tubes for water	Water treatment and wastewater management
Mechanical seals and sealing technologies	Resource efficiency
Polysilicon for solar panels	Cleaner and renewable Energy
Oil spill recovery booms barges and tanks	Environmental cleanup and prevention of damage
Waste containers	Waste management
Heat pumps	Cleaner and renewable Energy
Pumps for handling wastewater	Water treatment and wastewater management
Waste-elevators and conveyors	Waste management
Heat pumps	Cleaner and renewable energy
Metal shredders, Balers and Compactors	Waste management
Smart meters	Environmental monitoring
Photogammetrical surveying instruments	Environmental monitoring
Thermostats and other heat measuring devices	Environmental monitoring
Cork	Energy saving
Cork	Energy saving

Footnotes:

25. Source: EC (2016). Environmental Goods Agreement: Promoting EU environmental objectives through trade. Brussels, 22 January 2016. Brussels: European Commission.

education and access to information. Reduced costs and increases in market efficiency for relevant products could potentially impact environmental goals, with the modelling analysis in the report projecting a potential reduction of C02 emissions of almost 10 million tons of C02 by 2030 and a reduction of C02 intensity of gross domestic product (GDP) by 0.02% by 2030 as compared to the baseline scenario. It needs to be kept in mind however that this assessment was based on the APEC 54 voluntary list as well as the 153 product categories submitted by the 'Friends', since the actual EGA list of 304 products being negotiated at the time could not be made publicly available (EC, 2016b).

2.4. The Trade in Services Agreement

TiSA is a plurilateral trade agreement focusing on services. 23 members of the WTO are party to the negotiations, representing more than 1.6 billion people and a combined GDP of nearly USD 50 trillion in 2015.[26] Together the members account for approximately 70% of world trade in services (EC, 2016c).

The negotiations were launched in March 2013 by a group of like-minded countries and aim to further liberalize trade in services by enabling market access as well as developing new and strengthened services disciplines. While the negotiations are being pursued outside the WTO, the participants are building on the WTO GATS and aim to transform it into a WTO agreement by broadening the participation to all members. A large number of sectors are being negotiated, including environmental services. Negotiations have focused on a core text including general provisions as well as annexes on specific issues that include both cross-cutting or horizontal provisions applying to services (i.e. transparency and domestic regulation) as well as industry specific provisions (i.e. air transport services, financial services etc.) (Global Affairs Canada, 2017).

Parties have been negotiating ambitious commitments on environmental services covering all the main CPC sectors, namely 9401-Sewage Services, 9402-Refuse Collection and Disposal, 9403-Sanitation and Similar Services, 9404-Cleaning Services of Exhaust Gases, 9405-Noise Abatement Services, 9406-Nature and Landscape Protection Services and 9409-Other Environmental Protection Services, as well as the four modes of delivery. Members are nonetheless free to use their own classification methods and subheadings (Global Affairs Canada, 2017).

TiSA also provides for the inclusion of 'standstill' and 'ratchet' clauses. These however apply only to existing national treatment related measures that allow the party to discriminate and treat foreign services suppliers worse than domestic service suppliers but do not apply to market access measures. A standstill clause in a trade agreement means that the parties have to list all the barriers they have at the moment of taking commitments and afterwards cannot introduce any new barriers. A ratchet clause in a trade agreement means that a barrier, once unilaterally removed by a party in an area where it had made a commitment, cannot be reintroduced any more. Exceptions apply to sectors related to public services such as health, education and water distribution. Furthermore, both these clauses cannot affect the right of governments to introduce regulatory measures or standards so long as they are non-discriminatory (EC, 2016c).

Canada's market access request on environmental services with TiSA is reflective of the level of ambition sought in the negotiations. Referring to the 2015 SDGs, Canada states that further liberalization of environmental services would provide enhanced market access opportunities, including for SMEs, and improved health and environmental sustainability in TiSA markets. While Canada notes the important interplay between the liberalization of environmental services and the liberalization of related ancillary services

Footnotes

26. The 23 TiSA members comprise Australia, Canada, Chile, Chinese Taipei, Colombia, Costa Rica, the European Union, Hong Kong (China), Iceland, Israel, Japan, Liechtenstein, Mauritius, Mexico, New Zealand, Norway, Pakistan, Panama, Peru, Republic of Korea, Switzerland, Turkey, and the US.

such as construction, engineering, technical testing and analysis, and management consulting, its request on environmental services only touches upon UN CPC Prov. 94 and specifically excludes water for human use (collection, purification and distribution of natural water). It also excludes public utilities. Canada has asked for ambitious market access and national treatment commitments across all environmental service subsectors corresponding to UN CPC Prov 94 classifications. It also requests parties to schedule measures inconsistent with national treatment in their market access schedules and subject these to ratchet and standstill mechanisms. Canada has also requested full market access commitments across modes 1, 2 and 3 for environmental services and mode 4 commitments on intra-corporate transferees in the environmental service sector at a minimum (Global Affairs Canada, 2017).

Given that TiSA negotiations are ongoing, although they have been on hold since 2017, , details about all TiSA members' commitments in environmental services have so far not been made publicly available.

2.5. Inclusion of environmental goods and services in regional trade agreements

While limited progress has been made in negotiating multilateral trade agreements since 1995, RTAs present an alternative avenue through which countries can pursue trade liberalization. All 164 members of the WTO are now party to at least one RTA; as of 2014, each member had on average 11 RTA partners (Williams 20The benefits of RTAs are attributable to the elimination of duties and restrictive regulations on "substantially all trade" between the constituent parties except otherwise permitted under WTO rules.[27] The term "substantially all trade" however has not been clearly defined and has given rise to various interpretations, with some members for example deeming duty elimination to cover at least 90% of trade between parties.[28]

Given the expectation of substantial trade liberalization, it may be argued that the issue of defining environmental goods as a separate sector for liberalization may not be relevant, as most if not all goods would be subject to low or zero duties. Broad-based liberalization across HS 6-digit tariff headings would therefore automatically capture environmental goods. Similarly, comprehensive liberalization of the services sector would automatically liberalize market access for most if not all environmental services. It is revealing that of the 270 RTAs notified to the GATT or the WTO between 1956 and May 2016, provisions referring to trade in environmental goods, services and technologies are found in 129 agreements: 26 refer to the promotion of trade in environmental goods and services, 101 agreements contain schedules of commitments on environmental services, and only 2 contain an agreed list of duty-free environmental goods (Monteiro, 2016).[29] (See Annex 2 for a complete list of RTAs mentioning environmental goods and environmental services.) This implies that in the majority of RTAs notified, environmental goods were not singled out for special treatment and many were likely liberalized as part of overall tariff reduction for manufactured goods in general.

The type of provisions found in RTAs are quite heterogeneous ranging from (i) best-endeavour language promoting trade and foreign investment in environmental goods and

Footnotes

27. Article XXIV of the GATT Agreement

28. Paper by Japan (TN/RL/W/190).

29. The list on environmental goods mentions only notified RTAs with commitments related to "environmental goods", "environmental goods and services", "environmental goods, services and technologies" or "environmental technologies". The list does not include RTAs with only cooperation provisions referring to environmental industry found for instance in the China – Republic of Korea RTA. More generally, the list does not consider cooperation provisions in the environment or cooperation chapter referring to general sectors, such as agriculture or industry found for instance in EU-South Africa RTA. The list on environmental services mentions all notified RTAs referring to "environmental services" in their schedules irrespective of whether the parties made specific commitments in environmental services.

services to (ii) elimination of all tariffs on an agreed-upon list of environmental goods and (iii) specific commitments in environmental services.The most common provision found in 15 RTAs stipulates that parties shall strive or endeavour to facilitate and promote trade and foreign direct investment in environmental goods, services and technologies including through addressing related non-tariff barriers. Some examples of such 'best-endeavour' RTA provisions are listed in Table 2.2.

In addition to provisions specific to environmental goods and services, there are also provisions on not weakening or failing to enforce existing environmental laws and pledges to general provisions on environmental cooperation found in many RTAs, as well as more selectively in certain RTAs, pledges to achieve high levels of environmental protection, often accompanied by a pledge to strengthen the relevant laws over time. Inaddition, provisions also provide for cooperation in environmental matters notably in the case of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) to address environmentally harmful subsidies such as those on fisheries. Such provisions over the medium and long-term could also lead to a 'derived demand' effect for trade in ESTs. Table 2.3 provides some examples of these RTAs (UNEP and IISD, 2016).

There are also examples of 'cross-cutting' or horizontal provisions applying to all services sectors, which could facilitate market access in environmental service sectors as well. These may apply to measures regarding domestic regulation of services such as licensing requirements and technical standards. For example, in the EU- FTA, Chapter 8, Article 8.20 commits each party to ensuring that "...licensing and qualification procedures and formalities are as simple as possible and do not unduly complicate or delay the supply of the service." These types of provisions have become more widely used in recent agreements in this exact or similar form. Others may replicate language within the GATS.

2.6. Regional voluntary initiatives: The APEC Agreement on Environmental Goods

On 9 September 2012, leaders of the 21 APEC economies met in Vladivostok and agreed to voluntarily reduce applied tariffs on 54 product categories or HS subheadings containing environmental goods to no more than 5%. The list had been developed in the course of 2012 following the commitment, adopted in 2011, to reduce applied tariffs to 5% or less by the end of 2015, taking into account members' economic circumstances, and without prejudice to APEC members' positions in the WTO (APEC, 2012).

The agreement enshrined in the Vladivostok Declaration followed extensive negotiations among APEC economies and represents the first concrete trade liberalization outcome on a list of environmental goods among a large group of trading partners even though, given the voluntary nature of APEC, it is not a legally binding outcome. Despite this, the APEC economies have implemented the outcome, given the political weight behind the agreement.

While differences arose during the negotiations on issues such as product coverage and the inclusion of sensitive items, a final outcome was made easier as APEC members did not attempt to find a definition of environmental goods, but instead only agreed on 54 product categories that were acceptable to all members (Vossenaar, 2013).

Tariff reductions on product categories in the list may only happen for more narrowly defined 'ex-outs' rather than for the whole HS 6-digit subheading or product category. Table 2.4 shows the main environmental categories for product subheadings in the APEC list. The renewable energy and 'environmental protection' category (including solid and hazardous waste, wastewater management and air-pollution control) emerge as relatively important items on the list. In contrast, there is only one example of an EPP. It should be noted that each category, and even some of the more narrowly defined 'ex-outs', could also have non-environmental applications (Sugathan, 2013a).

A complete list of the 54 product categories can be accessed on APEC website.

Table 2.2 Examples of 'best-endeavour' provisions on environmental goods and services in RTAs

Regional Trade Agreement (s)	Nature of Provisions
• Comprehensive Economic and Trade Agreement (CETA) between Canada, and the EU and its Member States	Resolution "…to make efforts to facilitate and promote trade and investment in environmental goods and services, including through addressing the reduction of non-tariff barriers related to these goods and services."
• EU-Moldova • EU-Georgia	Agreement to promote trade in goods that contribute to environmentally sound practices, including goods that are the subject of voluntary sustainability assurance schemes such as fair and ethical trade schemes, eco-labels, and certification schemes for natural resource-based products.
• EFTA-Albania • EFTA-Bosnia and Herzegovina • EFTA-Montenegro • China-Switzerland	Parties shall encourage cooperation between enterprises in relation to goods, services and technologies that contribute to sustainable development and are beneficial to the environment.
• US-Morocco	As a priority for environmental cooperation, the promotion of the environmental technology business sector's growth and improvement of SME's awareness of opportunities to access global markets through improved environmental technologies, practices, and techniques.
• Nicaragua-Chinese Taipei	Cooperation to facilitate technology development and transfer and training related to clean production technologies, water protection, conservation and preservation, hazardous and non-hazardous waste management, and the monitoring and management of biodiversity and endangered species.
• Japan-Brunei Darussalam • Japan-Thailand	Encouragement of favourable conditions for the transfer and dissemination of technologies that contribute to the protection of the environment, consistent with the adequate and effective protection of intellectual property rights.
• EU-Colombia • EU-Peru	Facilitating the removal of trade and investment barriers to enable access to, innovation, development, and deployment of goods, services and technologies that can contribute to climate change mitigation or adaptation, taking into account developing countries' circumstances.
• Republic of Korea-Peru	Reference to parties' agreement to identify a list of environmental goods and services of mutual interest, modified upon request, and to facilitate their trade.
• Canada-Peru	Agreement on new collaboration to promote sustainable use of natural resources, forests management and use. It also highlights a commitment to the joint development of clean technologies, as a priority.

Source:

Adapted from Monteiro (2016), Gehring Markus et al. (2013) and UNEP and IISD (2016)

Table 2.3: Examples of other provisions with an environmental impact in RTAs

Regional Trade Agreement (s)	Nature of Provisions
• Comprehensive Economic and Trade Agreement (CETA) between Canada, of the One Part, and the EU and its Member States • EFTA-Hong Kong FTA • Panama-Chinese Taipei FTA	Commitment to not lower or relax enforcement of environmental laws in a way that affects trade and investment
• US-Morocco FTA	Pledge to achieve high levels of environmental protection and to improve those levels over time (aspirational commitment; non-enforceable)
• North American Working Group on Environmental Enforcement and Compliance Cooperation	Provisions for capacity building on environmental issues including enforcement and compliance cooperation such as programs on environmentally sound management of spent batteries.
• Euro-Med Agreements	Economic and sector cooperation including capacity-building provisions for 14 Mediterranean states.
• EC-Cariforum EPA	Technical assistance including: Technical assistance to producers in meeting relevant product and other standards applicable in markets of the EC Party; Promotion and facilitation of private and public voluntary and market-based schemes including relevant labelling and accreditation schemes; Technical assistance and capacity building, in particular to the public sector, in the implementation and enforcement of multilateral environmental agreements, including with respect to trade-related aspects; Facilitation of trade between the Parties in natural resources, including timber and wood products, from legal and sustainable sources; Assistance to producers to develop and/or improve production of goods and services, which the Parties consider to be beneficial to the environment; and Promotion and facilitation of public awareness and education programmes in respect of environmental goods and services in order to foster trade in such products between the Parties.
• NAFTA (Commission for Environmental Cooperation)	Commitment to work towards harmonization of environmental standards.

Source:
UNEP and IISD, 2016.

Table 2.4: Environmental categories for product subheadings in the APEC List[30]

Category	No. of product subheadings
Renewable Energy (RE)	15
Environmental Monitoring, Analysis and Assessment Equipment	17
Environmental-protection (principally SHW, WWM and APC)	21
Environmentally Preferable Products (multi-layered bamboo flooring panels)	1
Total	**54**

Almost all of the 54 product groups or subheadings in the APEC list had been included in submissions made during the course of Doha negotiations on environmental goods at the WTO. Only two product subheadings - (1) optical devices, appliances and instruments and (2) their parts - appear to be new. These include solar heliostats and their parts, which are used in the production of solar thermal power. Another observation is that for certain steam turbines, the final equipment is excluded, but their parts are included. In other cases, such as wind-energy equipment, the main turbine and related parts are included but other important parts are excluded. The exclusion of certain parts in the APEC 54 list could be due to concerns with their non-environmental uses. For example, while ball bearings are a critical component in wind-power projects, only a very small part of the overall trade in ball bearings is driven by the deployment of wind technologies (Sugathan & Brewer, 2012).

The APEC agreement is also significant in that APEC economies make up some of the most important traders in the 54 product categories. For most economies, the tariffs were already at 5% or below for the majority of products on the list. However, in certain cases, such as wind-powered generating sets, where several APEC economies including China, Indonesia, the Republic of Korea and Chile applied tariffs greater than 5%, and solar water-heaters,where China for example applied tariffs of up to 35%, the APEC outcome will lead to real and meaningful market access (Vossenaar, 2013).

Finally, unlike in the case of RTAs, the benefits of the APEC outcome will be extended to the rest of the WTO membership on a MFN basis. The agreement will have an important and positive “signalling” effect to the WTO as well as to other regional trade blocs that want to undertake similar initiatives (Vossenaar, 2013). It should be noted, however, that the APEC negotiations did not address non-tariff barriers or barriers to trade in services.

A review of the implementation plans for various APEC economies by Vossenaar (2016) indicates that applied tariffs for selected goods were to be reduced to 5% or even lower by 2016. Some APEC economies have liberalized in a broad manner at the HS 6-digit subheading level (e.g. Brunei Darussalam and Chile), even possibly including many goods with a non-environmental end-use. Others have been much more specific about the particular national tariff lines to be liberalized under each of the 54 HS 6-digit

Footnotes

30. Source: Vossenaar (2013) and Sugathan (2013a).

subheadings. These are indicated as "yes" in their implementation plans. Often the 'ex-out' descriptions indicated in the APEC list are too narrow to be captured by many countries' existing national tariff lines. In such cases APEC economies are free to create additional national tariff lines in case they wish to be much more specific in order to strictly liberalize only the 'ex-out' description mentioned. Mexico, for instance, has created nine new tariff lines. Based on the implementation plans, it is found that APEC economies collectively had some 375 tariff lines that required tariff reduction. Brunei Darussalam, the Republic of Korea, China and Mexico have implemented the largest number of tariff reductions, both in terms of national tariff lines and HS subheadings covered. Malaysia, Brunei Darussalam and Mexico applied the deepest tariff cuts.

While many goods in the APEC 54 list already enjoyed duty-free market access or market access at or below 5% duty rates in many APEC economies even before the APEC deal, the tariff-cuts under the deal still benefited many products. Examples of environmental goods benefiting from tariff reductions across a relatively large number of APEC economies include solar water heaters, floor coverings of bamboo, wind-powered generating sets and key components of the wind-energy value chain, other electric generating sets (mostly for generating electricity from renewable sources of energy), equipment for filtering or purifying water or gas, and waste incinerators. For the 54 HS subheadings, the import value of APEC economies' in national tariff lines with an MFN-applied tariff of over 5% — before the implementation of tariff cuts — was estimated at around USD 31 billion in 2014. This highlights the potential for further increases in trade resulting from meaningful tariff reductions. It should be noted, however, that this figure also includes trade in tariff lines that are not covered by the APEC list of environmental goods (Vossenaar, 2016). At the time of writing, according to interviews with experts,[31] the APEC agreement has been implemented by most APEC economies although there are still some gaps with regard to implementation among some APEC economies, notably Chile, Indonesia and Thailand (WTO, n.d.-c).

2.7. Environmental credibility and participation of the environmental community in negotiations

Given the definitional challenges associated with negotiating environmental goods and services liberalization, it is important that trade negotiators receive adequate input from relevant stakeholders during the negotiating process. Growing awareness about the linkage between trade and environmental issues have led to increasing engagement of WTO members with environmental experts and institutions as well as civil society. This was reflected during the Doha Round of negotiations and in various RTA negotiations, where WTO members solicited and considered the views of industry, civil society environmental experts and organizations including the United Nations Environment Programme (UN Environment) and the Global Ecolabelling Network.

This strengthening of this engagement has led to some tangible results. For example, in its submission of 5 July 2005, the European Communities make more explicit their willingness to include some EPPs based on PPMs including, among others, those identified by, "an eco-label issued by a labelling scheme included in the existing international Global Ecolabelling Network, which covers both developed and developing countries."[32] In addition, a number of developing countries as well as civil society groups have voiced their opposition to the inclusion of 'water for human use' within the scope of environmental services (Kirkpatrick, 2006). As a result this services segment has largely been excluded from the scope of environmental services liberalization, not only during the Doha Round negotiations under Paragraph 31 (iii), but also under TiSA.

Footnotes

31. Interview with Rene Vossenaar, independent consultant and APEC Secretariat experts.

32. European Communities. *Environmental Goods*. Submission to the World Trade Organization, TN/TE/W/56, July 2005.

As negotiations progressed, WTO members also included an environmental benefits and rationale column next to their product submissions to highlight the environmental credibility or relevance of the HS subheading or 'ex-out' product that was proposed. Climate change mitigation, forests and biodiversity protection, prevention of soil erosion, air, remediation of air, soil and water pollution, and energy efficiency were some of the environmental objectives to which the various products submitted were linked. There were also references to the delivery of internationally and regionally agreed policy objectives and action plans such as the Agenda 21, the Johannesburg Plan of Implementation and the Kyoto Protocol. For instance, in a 2005 submission to the WTO's CTE, the EU stated that " multilateral environmental agreements and the Millennium Development Goals, in particular on access to safe water and sanitation, could provide useful guidance on the environmental objectives relevant for the identification of environmental goods."[33] Similarly, in its proposal for liberalizing natural gas fired generation systems and advanced gas generation systems, Qatar has referred to the Kyoto Protocol and Intergovernmental Panel on Climate Change Assessment Reports that recommended increased use of natural gas over other fossil fuels as a way to reduce greenhouse gas emissions.[34]

During the course of the EGA negotiations, the EU conducted a Trade Sustainability Impact Assessment (Trade SIA) to analyse the potential economic, social and environmental impacts of the EGA and, as part of this process, sought broad stakeholder input including from industry groups and civil society organizations.

2.8. Conclusion and outlook

In the light of setbacks at the multilateral level for environmental goods and services negotiations, there is a clear trend towards plurilateral and regional negotiations. Nevertheless, these types of agreements - like multilateral agreements - are not easily won, as demonstrated by the stalling of both TiSA and the EGA. The APEC outcome represented an easier first step to tackle environmental goods as it was a voluntary process where members reduced MFN-applied tariffs rather than bound ceiling tariffs (as in the case of the EGA). Bound tariffs are always more challenging to negotiate as the tariff reductions are then irreversible.

Another encouraging trend is the large number of references to co-operation on environmental goods and services in RTAs that also include developing country members outside the EGA. Indeed, the reach of RTAs in terms of the countries they cover, from major players in the trade of environmental goods and services, to countries that are not currently party to the EGA negotiations or APEC agreement, such as India, Colombia, and Brazil, means they can have a major impact. A growing number of RTAs now prioritize environmental protection and include chapters on environment and/or sustainable development as well as specific commitments on environmental services. At the same time many RTAs make provisions for accommodating sensitive products, for instance by allowing for longer liberalization time-frames for certain categories of goods.

RTAs, by their very nature, are more ambitious in terms of their scope for liberalization and often cover entire HS 6-digit subheadings irrespective of 'dual-use' or environmental end-use, thus automatically including a potentially significant number of environmental goods. They also increasingly include provisions on addressing non-tariff barriers and technology cooperation.

All of these trends suggest that in the near to medium term scenario, plurilateral agreements and RTAs may be a more effective vehicle for meaningful liberalization of

Footnotes

33. European Communities. Environmental Goods. Submission to the World Trade Organization, TN/TE/W/56, July 2005.

34. Submission by Qatar, Negotiations on Environmental Goods: Efficient, Lower-Carbon and Pollutant Emitting Fuels and Technologies, TN/TE/W/ 19.

ESTs, both for environmental goods as well as for environmental services. This is despite the criticism that they represent a less optimal outcome relative to multilateral trade liberalization due to the risk of trade-diversion away from the most efficient producers of ESTs. In order to be consistent with WTO rules, plurilateral agreements are required to extend their benefits to all WTO members, even non-participating ones. RTAs could serve as effective building blocks and templates for eventual liberalization at the multilateral level when the political climate becomes more conducive. The valuable environmental gains and experience arising from plurilateral and regional initiatives could also inform the eventual contours of a multilateral trade agreement on ESTs.

3. Trade flow analysis

In this chapter, trade flows of the selected ESTs are mapped out and analysed. Section 3.1 looks at global trends, while Sections 3.2-3.4 take a closer look at the trade flow patterns by main category (namely air pollution control, clean up or remediation of soil and water, EPP, renewable energy, solid and hazardous waste management and wastewater management and water treatment), country and product respectively. Section 3.5 then limits the selected EST-EGs to a smaller sample of goods with clearer environmental end-use. Section 3.6 presents the relative comparative advantage analysis, followed by an intra-industry trade analysis in Section 3.7. Section 3.8 focuses on the services component of ESTs.

Based on the objectives of the study and focus on developing countries, a list of ESTs was developed across five product categories. Four of the categories are within EST-EGs, namely air pollution control (APC), wastewater management (WWM), solid and hazardous waste management (SHWM) and renewable energy (RE). Additionally, EPPs were identified as the fifth important category. The list of ESTs was compiled based on a review of existing environmental goods lists and relevant literature on the topic of environmental goods and services trade in developing countries. Using the "Friends of the Earth" 153 List (WTO, 2005) as a starting point, ESTs were added to or excluded from the list based on the criteria included in existing literature[35] and previous discussions in the project group. After the review, 144 ESTs were grouped by their product category and classified using their 6-digit HS classification, as a starting point for the trade analysis. To ensure meaningful cross-country comparisons, a standardization procedure was applied to the dataset. Values in the figures in this chapter are reported in current USD, except where otherwise specified. This trade analysis, referred to in the rest of the report as 'Category 1', is useful to view overall trends of ESTs-EGs and EPPs. Annex 1 provides the complete list of products used in the Category 1 analysis of the next section.

The Category 1 analysis includes many ESTs that are traded within HS subheadings of multiple end uses. A commonly recognized hurdle in any analysis of trade in environmental goods and services - the lack of specification of ESTs at the HS six-digit level - was again recognized in the analysis. The focus on global trade value as the identifier of the top ten ESTs therefore produced a list of ESTs specified by broad HS codes. Multiple end-uses and applications result in a higher number of technologies traded under one subheading, resulting in larger values unreflective of the ESTs in the group. It was therefore decided to select a more specific list of ESTs with clearer end-uses for 'Category 2' of the trade analysis.

The Category 2 list consists of ESTs with a clearer environmental end-use. Those ESTs with especially broad subheadings were excluded. The ESTs selected under the second

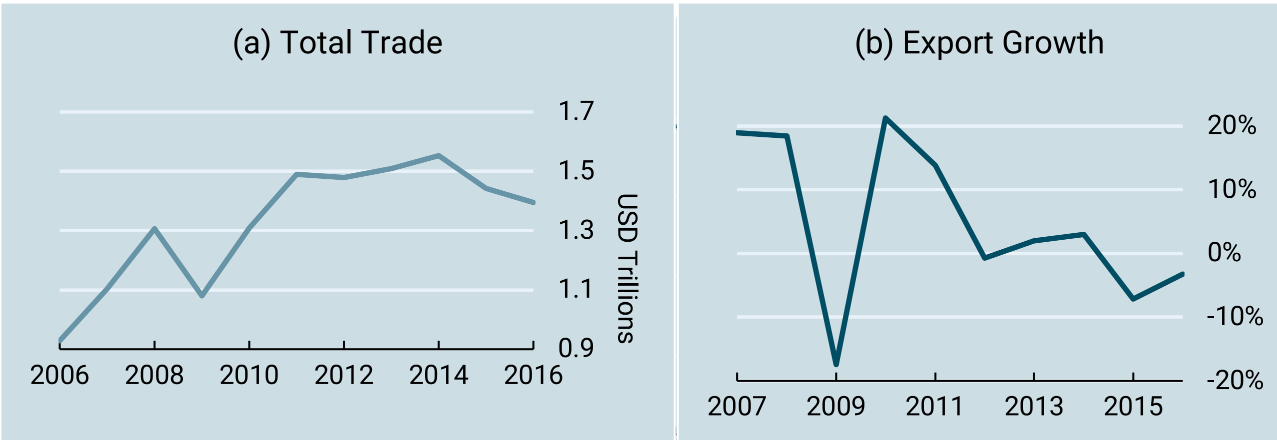
Footnotes

35. Araya (2016); ASEAN-SHINE (2016); ICTSD (2008); Jha (2008); Knudson, et al. (2015); UNEP (2014); WTO (2005).

category have been identified and emphasized for further analysis based on their relevance to achieving the objectives of the product categories selected at the beginning of the project, i.e. APC, WMWT, SHWM, RE and EPPs, the ability to determine their end-use, and their presence in multiple existing environmental good lists.

3.1. Trends in trade of selected EST-environmental goods (Category 1)

Figure 3.1: Values and growth rate of world trade in selected EST-EGs



Note: Total value of trade is calculated as the sum of exports and imports.

Source: author calculations based on Comtrade data.

Global trade[37] in the selected environmental goods increased from USD 0.9 trillion in 2006 to its peak at USD 1.6 trillion in 2014, before reducing to USD 1.4 trillion in 2016 (Figure 3.1a). Although the BRIC countries' exports of EST-EGs have nearly tripled since 2002, China's share in total trade of the BRIC countries has remained roughly stable.

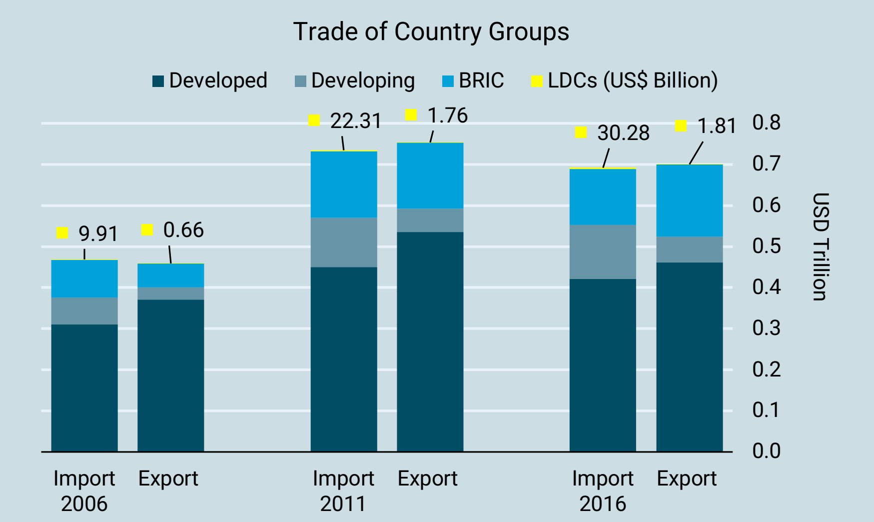
From 2006 to 2016, developing countries accounted for a small, but increasing, portion of the global imports of EST-EGs. Import values have been growing relatively more than export values for developing countries. As of 2016, developing countries' imports of selected EST-EGs reached USD 0.13 trillion, accounting for 18% of total world imports. Between 2006 and 2016, LDCs only accounted for a minor fraction of global EST-EGs trade. Developing countries, on the other hand, doubled the value of exports of EST-EGs since 2006.

Footnotes

36. Brazil, Russia, India and China

37. Data may over estimate trade flows as many of the HS subheadings do not contain environmental goods.

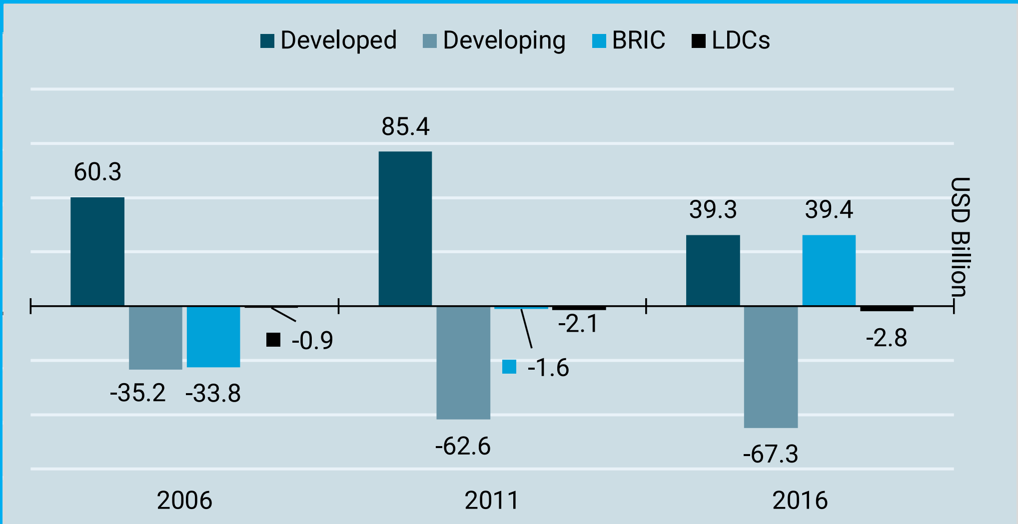
Figure 3.2 Imports and exports of EST-EGs by different economy groups



Source: author calculations based on Comtrade data.

Note: **Numbers are in USD trillion for developed, developing and BRIC countries and in USD billion for LDCs**

Figure 3.3 Balance of trade in EST-EGs by development of economy



Source: author calculations based on Comtrade data.

As presented in Figure 3.3, developed countries make up the majority of world EST-EGs trade-surplus, though this fell to USD 39.3 billion in 2016, which was similar in magnitude to the trade surplus of BRIC countries in that year (USD 0.14 trillion of imports and USD 0.18 trillion of exports).

In the last decade, BRIC countries went from being net importers with a USD 33.8 billion trade-deficit to net exporters of these EST-EGs, showing a USD 39.4 billion trade-surplus, which is almost equivalent to that of the developed countries (Figure 3.3). This trend appears to have been driven almost entirely by China, which accounted for 93% and 71% of total BRIC exports and imports respectively.

In recent years, however, developing country EST-EG exports to the world fell significantly, leading to an increasing trade-deficit from USD 35.2 billion to USD 67.3 billion. LDCs' participation in EST-EGs trade is markedly more limited. Developed countries account for more than half of global export and import flows of EST-EGs. BRIC countries dominate developing country trade flows in terms of exports.

3.2. Trends in trade of selected EST-environmental goods by main categories (Category 1)

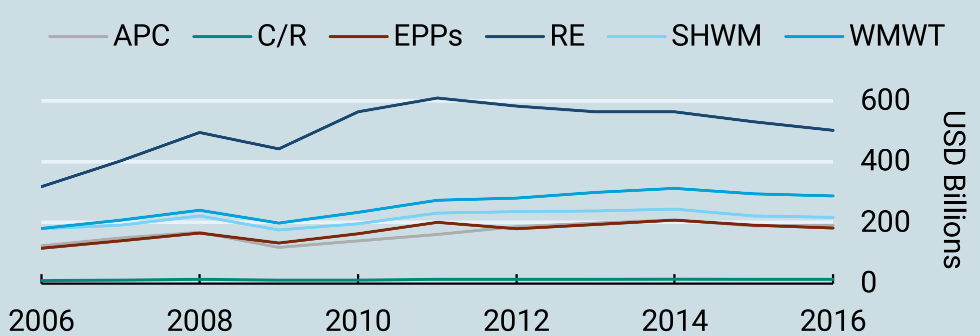
RE technologies comprise the biggest part of EST-EGs trade (Figure 3.4). RE technology trade accounted for more than USD 609 billion in 2011 at its peak, and USD 503 billion in 2016, accounting for 36% of total EST-EGs trade.

Wastewater management and water treatment (WMWT) followed RE technologies, with a trade value close to USD 300 billion in 2016, followed by solid and hazardous waste management (SHWM), air pollution control (APC), EPPs, and clean up or remediation of soil and water (C/R).

Figure 3.5 shows that developed countries played a leading role in trade of selected EST-EGs in all of the above categories. Developing countries witnessed a growing share in trade of RE technologies, WMWT, and SHWM.

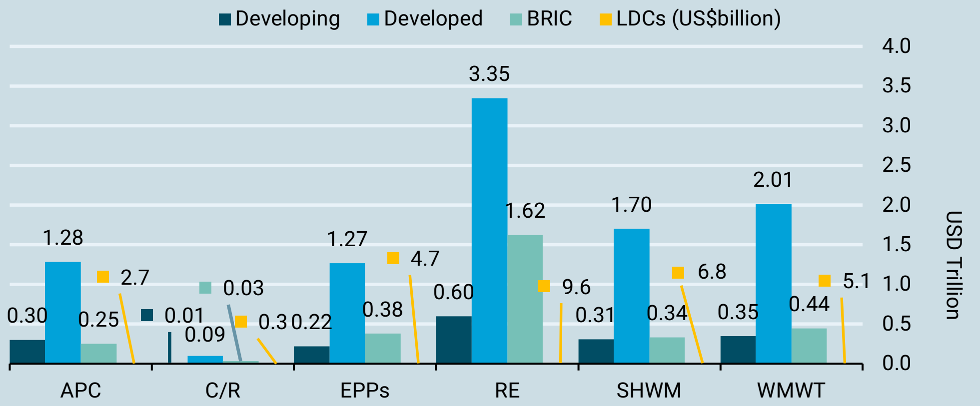
Figure 3.6 shows that world trade in selected environmental goods is largely concentrated in three regional hubs: Germany in Europe, the US in North America and China in East Asia. Germany and the US together account for about 30% of trade in each

Figure 3.4 World trade in EST-EGs by main ESTs categories



Note: APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment. Total value of trade is calculated as the sum of exports and imports.
Source: author calculations based on Comtrade data.

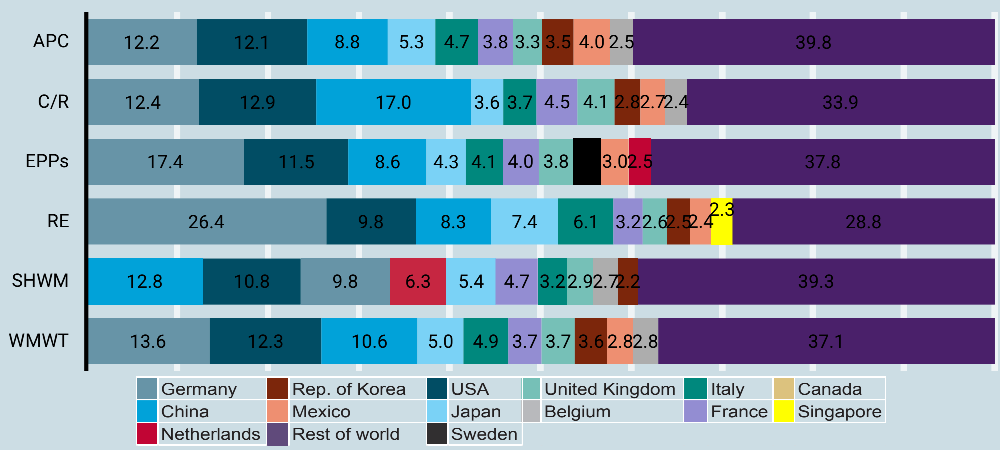
Figure 3.5 Total trade of EST-EGs by main ESTs categories and development of economy over the past ten years, between 2006 and 2016.



Note: APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment . Total value of trade is calculated as the sum of exports and imports.
Source: author calculations based on Comtrade data.

Note: Numbers are in USD trillion for developed, developing and BRIC countries and in USD billion for LDCs

Figure 3.6 Participation of top-10 countries (% of total trade value) in trade of EST-EGs by main ESTs categories over past ten years, between 2006 and 2016.



Note: APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment . Total value of trade is calculated as the sum of exports and imports.
Source: author calculations based on Comtrade data.

category. Among developing countries, China dominates trade in ETS-EGs, highlighting its role as a global manufacturing hub. Outside Germany, the US and China, the rest of the world collectively contributes about 30% to 35% to each category.

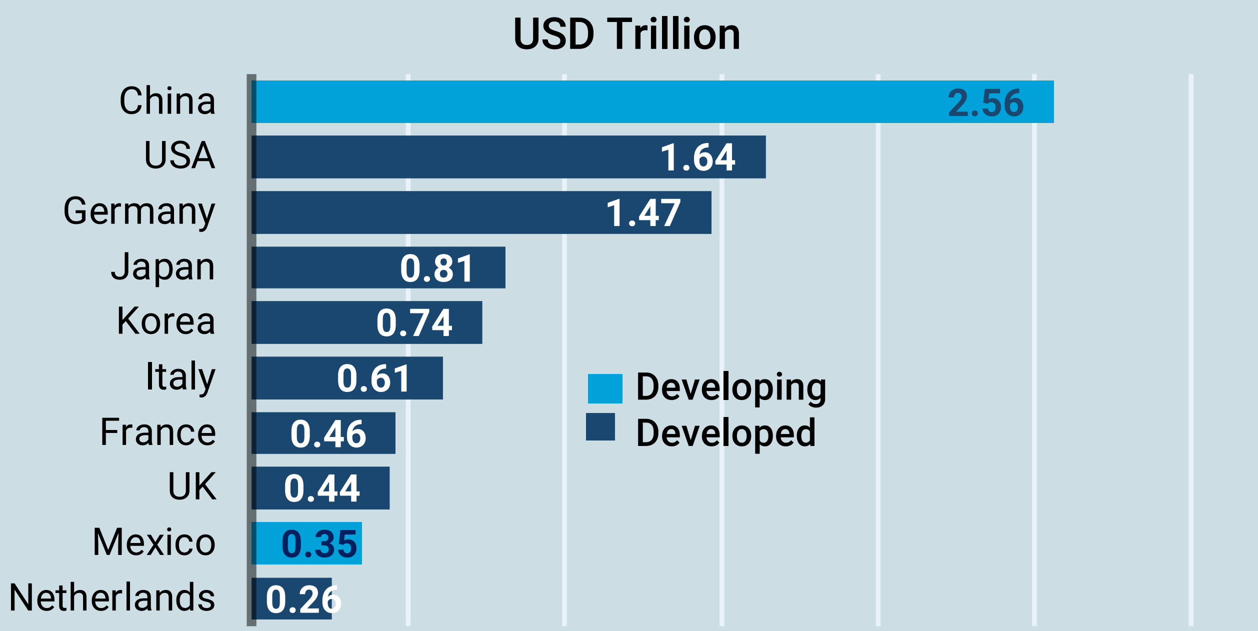
3.3. Trends in trade of selected EST-environmental goods by countries (Category 1)

Figure 3.7 displays the top-10 countries in terms of trade value of the selected EST-EGs between 2006 and 2016. China and Mexico are the only two developing countries in the list, with China at the top (USD 2.56 trillion).

Figure 3.8 shows that six of the top 10 developed country importers and exporters of EST-EGs are European countries with Germany ranking as the top importer and exporter of EST-EGs within the EU (as compared to Figure 3.7).

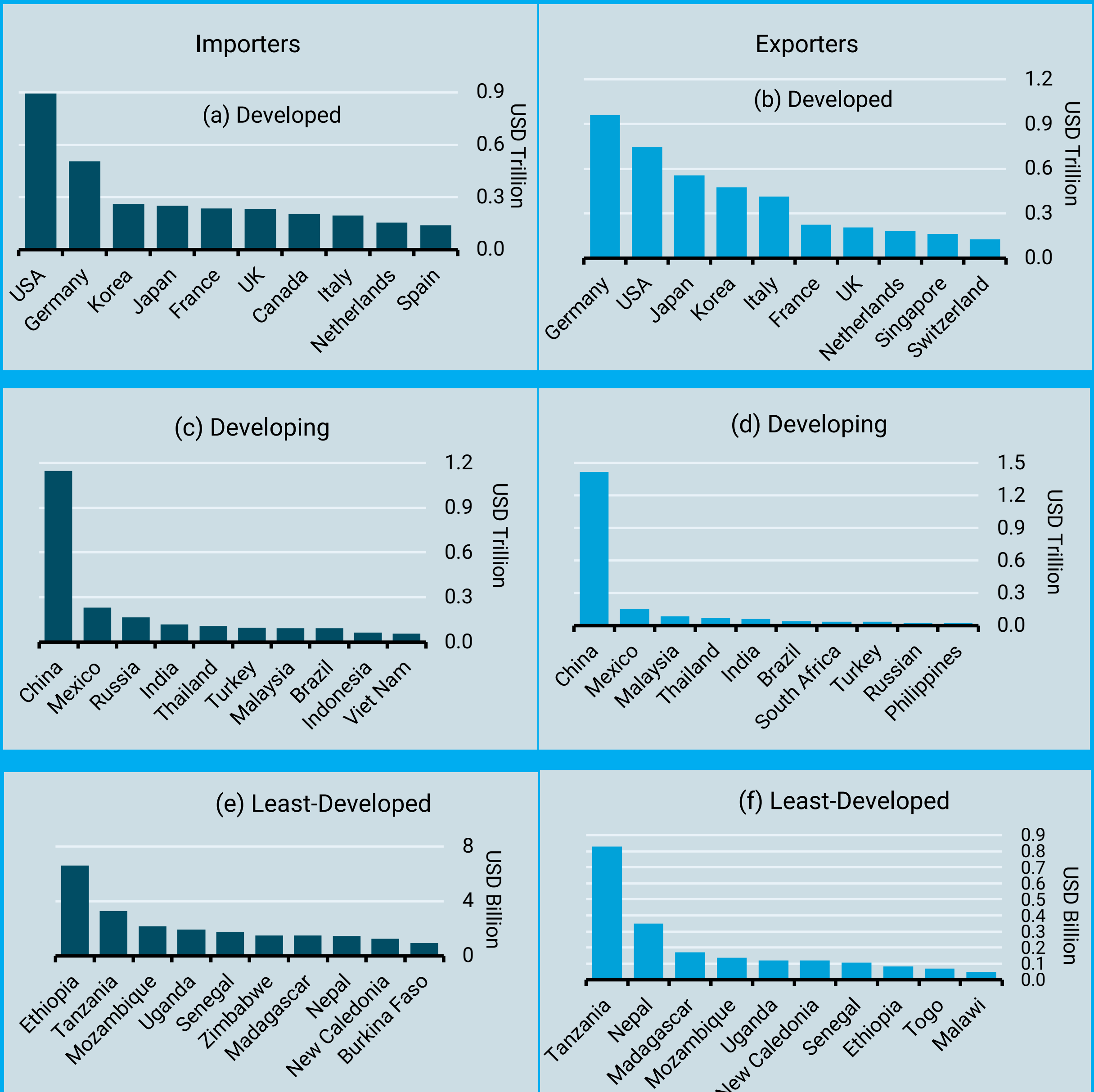
In terms of developing countries, China recorded the highest value of imports followed by Mexico, Russia, India, Thailand Turkey, Malaysia, Brazil, Indonesia and Viet Nam. China has also become a leading exporter amongst developing economies over the past decade.

Figure 3.7 Total value of top-10 countries in trade of EST-EGs, over 2006-2016



Note: Total value of trade is calculated as the sum of exports and imports.
Source: author calculations based on Comtrade data.

Figure 3.8 Top-10 countries' imports and exports of EST-EGs over 2006-2016



Source: author calculations based on Comtrade data.

3.4. Trends in trade of EST-environmental goods by product (Category 1)

Table 3.1 displays the value of world trade in the top-10 EST-EGs. In terms of value, a large amount of world trade relates to HS 901380 (Optical instruments (solar heliostats) products), amounting to USD 1.23 trillion. In contrast, HS 854140 (PV module, wafers, cells), which covers the majority of South-South trade in RE goods in value terms (UNEP, 2014), represented a smaller portion of world trade in terms of value (USD 0.97 trillion of total trade).

Table 3.2 presents the top-10 leading countries in terms of imports, exports and total trade flows of the top-5 environmental products. China is the top exporter and importer across almost all the top-five traded EST-EGs listed, accounting for roughly USD 1,300 billion of trade over the decade. The US was the top importer of HS 848180 and HS 850440, accounting for almost USD 160 billion worth of imports, while Germany was the top exporter of HS 847989, accounting for USD 72.4 billion work of exports.

Figure 3.9 illustrates the share of world trade of each top-5 EST-EG with a breakdown by country. As of 2006, China has been positioned as the main trader of a number of goods. China accounts for about 60.2% of the total value of trade of HS 901380 and about 20.2% of exports of HS 850440. Other developing countries do not participate substantially in trade in the aforementioned subheadings, while they are important players in goods trade among subheadings HS 854140, HS 848180 and HS 847989. Total trade of Japan in HS 854140 accounts for the largest share in its trade flow of top-5 EST-EGs. HS 850440 represent the most significant share of US trade flows. Total trade of Germany and the Republic of Korea is most significant in trade of HS 854140 and HS 901380.

Table 3.3 depicts imports and exports of the top-5 EST-EGs by developing countries between 2006 and 2016. It shows that China dominates each subheading in the developing group in terms of both exports and imports. Other major players include Mexico, India, Malaysia, Russia, Brazil and Thailand.

Panel A of Table 3.4 reports the total value of trade for the top-10 EPPs in 2016. The bulk of EPP trade concerns HS 382490 (biodiesel). HS 940540 (solar powered lamps and fittings) and HS 940510 (chandeliers and other electric ceiling or wall light fittings), while other subheadings account for a much lower share. Panel B of Table 3.4 highlights the top-10 countries that trade EPPs, grouped in developed, developing and LDC categories for the same year. In 2016, world trade in EPPs mainly related to the US (USD 23.1 billion), China (USD 44.7 billion) and Germany (USD 13.8 billion). Other countries have contributed, but less significantly in value terms. The US and China are the biggest traders of EPPs in the devleoped and developing group, respectively. The values of EPPs trade of LDSc reamins limited compared with other developing countries.

Table 3.1 Total trade, imports and exports of EST-EGs over 2006-2016 (USD trillion)

Rank	HS-6 Code	End-use	Total
		Imported	
1	901380	Optical instruments (solar heliostats)	0.61
2	854140	PV module, wafers, cells	0.50
3	848180	Taps, cocks, valves & similar appliances	0.46
4	850440	Static converters	0.44
5	382490	Biodiesel	0.35
6	847989	Machines and mechanical appliances	0.35
7	854370	Ozone generators for water purification	0.24
8	841199	Parts of gas turbines	0.20
9	841480	Industrial hoods, aerators, blowers and diffusers	0.20
10	850300	Parts for electricity generators	0.18
		Exported	
1	901380	Optical instruments (solar heliostats)	0.61
2	854140	PV module, wafers, cells	0.50
3	848180	Taps, cocks, valves & similar appliances	0.46
4	850440	Static converters	0.44
5	382490	Biodiesel	0.35
6	847989	Machines and mechanical appliances	0.35
7	854370	Ozone generators for water purification	0.24
8	841199	Parts of gas turbines	0.20
9	841480	Industrial hoods, aerators, blowers and diffusers	0.20
10	850300	Parts for electricity generators	0.18
		Traded	
1	901380	Optical instruments and then mention solar heliostats in brackets	1.23
2	854140	PV module, wafers, cells	0.97
3	848180	Taps, cocks, valves & similar appliances	0.92
4	850440	Static converters	0.86
5	382490	Biodiesel	0.72
6	847989	Machines and mechanical appliances	0.71
7	854370	Ozone generators for water purification	0.46
8	841199	Parts of gas turbines	0.42
9	841480	Industrial hoods, aerators, blowers and diffusers	0.40
10	850300	Parts for electricity generators	0.37

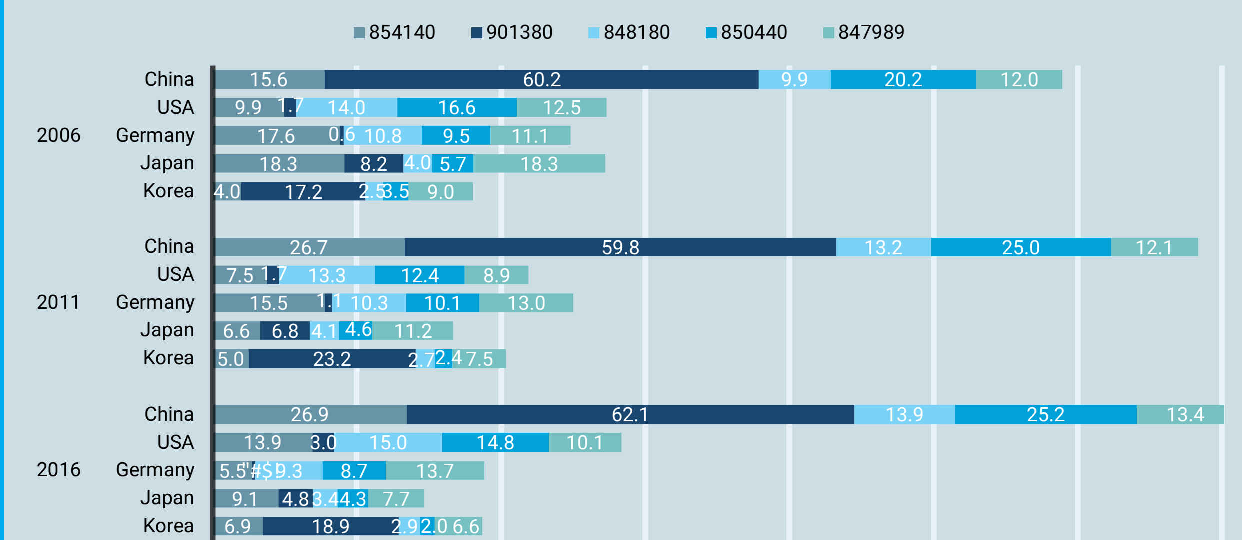
Table 3.2 Leading importers and exporters of top-5 traded EST-EGs between 2006 and 2016 (USD billion)

854140. Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules/made up into panels; light emitting diodes (Rank 1)			
Imports		**Exports**	
China	77.7	China	173.9
Germany	75.7	Japan	57.6
USA	60.1	Germany	49.5
Japan	39.5	Korea	29.7
Italy	32.9	Malaysia	26.4
901380. Liquid crystal devices not constituting arts. provided for more specifically in oth. headings; oth. optical appls. & instr. (Rank 2)			
Imports		**Exports**	
China	465.9	China	293.1
Mexico	35.2	Korea	239.5
Korea	21.8	Japan	52.3
USA	14.9	USA	9.3
Slovakia	14.8	Germany	3.4
848180. Taps, cocks, valves & sim. appls. for pipes/boiler shells/tanks/vats or the like, incl. thermostatically controlled valves. (Rank 3)			
Imports		**Exports**	
USA	73.4	China	83.9
China	35.1	Italy	61.7
Germany	28.4	Germany	61.4
Canada	21.0	USA	52.4
UK	20.0	Japan	20.3

Table 3.2 Leading importers and exporters of top-5 traded EST-EGs between 2006 and 2016 (USD billion) (continued)

850440. Static converters (Rank 4)			
Imports		**Exports**	
USA	83.6	China	148.8
China	64.7	Germany	48.2
Germany	32.1	USA	36.3
Japan	21.2	Japan	18.0
Mexico	17.3	Netherlands	14.9
847989. Machines & mech. appls. having individual functions. (Rank 5)			
Imports		**Exports**	
China	69.0	Germany	72.4
USA	31.2	Japan	63.7
Korea	25.7	USA	40.2
Germany	20.5	Italy	30.4
Mexico	14.2	Korea	26.8

Figure 3.9 Participation of top-5 countries in trade of top-5 EST-EGs (% of total trade value of a technology)



Note: 854140,PV module, wafers, cells; 901380, Optical instruments and then mention solar heliostats in brackets; 848180,Taps, cocks, valves & similar appliances; 850440,Static converters; 847989, Machines and mechanical appliances.
Source: author calculations based on Comtrade data.

Table 3.3 Leading developing countries of top-5 traded EST-EGs over 2006-2016 (USD billion)

854140. Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules/made up into panels; light emitting diodes (Rank 1)			
Imports		**Exports**	
China	77.7	China	173.9
Mexico	11.5	Malaysia	26.4
India	10.7	Philippines	7.8
Malaysia	6.4	Mexico	7.1
Thailand	5.1	Thailand	3.3
901380. Liquid crystal devices not constituting arts. provided for more specifically in oth. headings; oth. optical appls. & instr. (Rank 2)			
Imports		**Exports**	
China	465.9	China	293.1
Mexico	35.2	Mexico	2.4
Brazil	6.2	Malaysia	1.2
Malaysia	5.5	Viet Nam	0.5
India	2.5	Russia	0.2
848180. Taps, cocks, valves & sim. appls. for pipes/boiler shells/tanks/vats or the like, incl. thermostatically controlled valves. (Rank 3)			
Imports		**Exports**	
USA	73.4	China	83.9
China	35.1	Italy	61.7
Germany	28.4	Germany	61.4
Canada	21.0	USA	52.4
UK	20.0	Japan	20.3
850440. Static converters (Rank 4)			
Imports		**Exports**	
China	64.7	China	148.8
Mexico	17.3	Philippines	10.9
Russia	7.1	Thailand	9.3
India	7.0	Mexico	8.5
Brazil	5.8	India	4.4
847989. Machines & mech. appls. having individual functions. (Rank 5)			
Imports		**Exports**	
China	69.0	China	14.3
Mexico	14.2	Mexico	5.8
Russia	9.2	Brazil	2.8
India	8.1	Malaysia	2.8
Brazil	7.2	India	2.2

Table 3.4 Trade in EPPs in 2016

Panel A: Top-10 traded EPPs

Rank	HS-6 Code	End-use	Total
1	382490	Biodiesel	58.9
2	940540	Solar powered lamps and fittings	40.8
3	940510	Chandeliers and other electric ceiling or wall light fittings	29.4
4	290511	Methanol	10.5
5	732111	Solar powered stoves / appliances	9.2
6	851310	Portable electric lamps designed to function by their own source of energy	6.1
7	853931	Electric filament or discharge lamps: Flourescent, hot cathode	5.3
8	441782	Other assembled flooring Panels, Multilayer, of bamboo	3.8
9	732290	Solar air heaters	2.6
10	732190	Parts for 732111, Solar powered stoves / appliances	2.6

Panel B: Top-10 countries in EPPs trade across developed, developing, and least-developed countries

Rank	Developed	Total	Developing	Total	LDCs	Total (USD million)
1	USA	23.1	China	44.7	Ethiopia	117.2
2	Germany	13.8	Mexico	4.9	Nepal	105.1
3	France	6.3	India	2.7	Tanzania	102.2
4	Japan	6.3	Malaysia	2.1	Togo	33.5
5	Italy	5.5	Turkey	2.0	Uganda	31.3
6	Netherlands	5.4	Russia	1.6	Mozambique	25.3
7	UK	5.1	Thailand	1.4	Burkina Faso	23.2
8	Canada	4.2	Brazil	1.2	Madagascar	20.9
9	Belgium	4.2	Indonesia	1.2	Rwanda	18.9
10	Korea	4.1	Viet Nam	1.1	Senegal	13.4

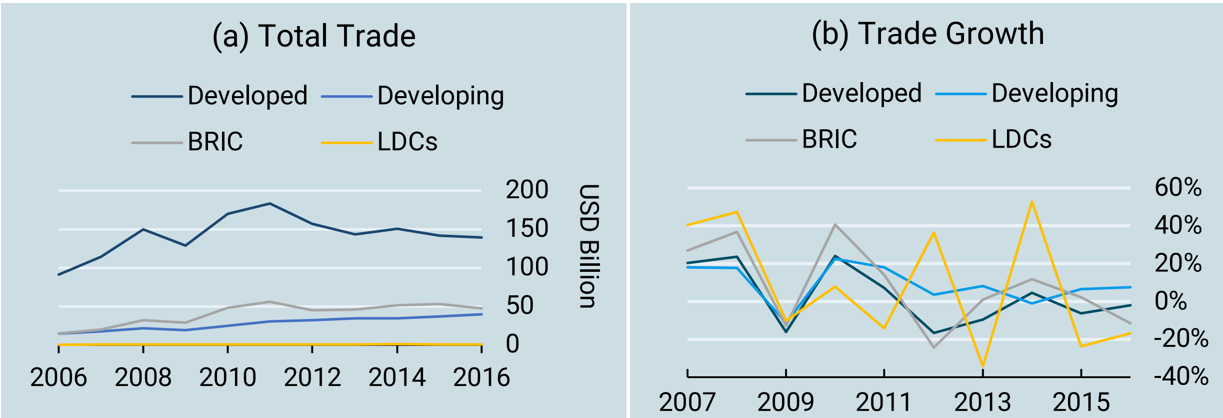
Note: **Total value of trade is calculated as the sum of exports and imports and presented in USD billion for developed and developing countries and in USD million for LDCs.**

3.5. Overall trends in trade of selected EST-environmental goods with clearer environmental end-use (Category 2)

The paper mainly uses international trade statistics sourced from the UN Comtrade database, in which HS subheadings are used to classify EST-EGs. This, however, tends to cover trade in a broader range of products, which makes it difficult to determine the end-use of many EST-EGs. Therefore, values in the aggregate estimates may not solely represent EST-EGs but also a lot of non-environmental goods as well. In only a few cases, such as wind-powered generating sets (HS 850231), do 6-digit HS subheadings exclusively or predominantly cover environmental goods (UNEP, 2014). In other cases, a large HS subheading by value at the HS-6 level (such as optical instruments) may actually contain a very small share of environmental goods (solar heliostats in the case of optical instruments).

To solve this problem, this study identifies a shorter list of EST-EGs for further sustainability impact assessment based on their relevance to the EST categories, existing literature, ease to determine the end-use, presence on multiple environmental goods-lists, and applicability in developing country contexts.[38]

Figure 3.10 Trade of selected EST-EGs by development of economy, 2006-2016



Note: Total value of trade is calculated as the sum of exports and imports.
Source: author calculations based on Comtrade…

Source: author calculations based on Comtrade data.

Figure 3.10a shows that developed economies remain the leading group in trade of selected EST-EGs, followed by the BRIC countries and developing countries. Figure 3.10b indicates that the largest increase in the value of world trade in selected EST-EGs appeared in 2010 for developing, developed and BRIC countries, while growth in trade value has slowed down substantially in the last few years since 2010, except for LDCs.

Figure 3.11 reports several notable upturns that appeared between 2006 and 2016. The increase in imports turned the developed countries as a group to net importers of EST-EGs. Between 2011 and 2016, the BRIC countries have collectively become net exporters (Figure 3.12). As of 2016, developing countries as a group remain a net importers.

Footnotes

38. See Annex 1 for a list of EST-EGs with clearer environmental end-use.

Figure 3.11 Imports and exports of selected EST-EGs by development of economy

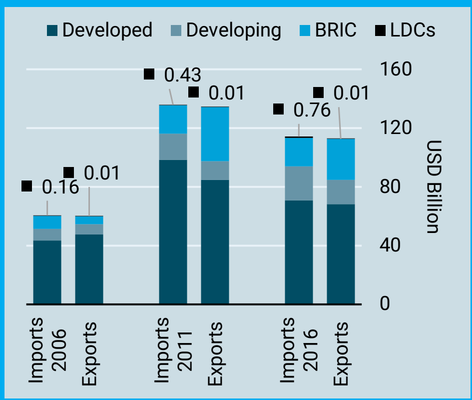
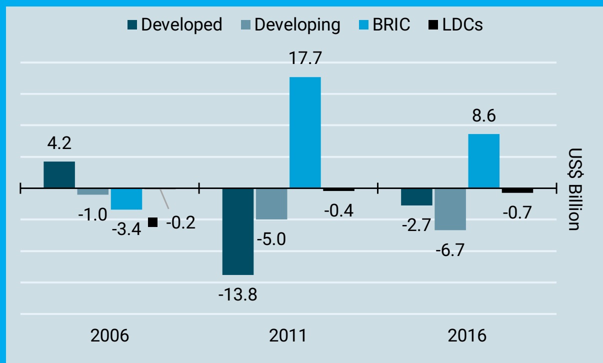


Figure 3.12 Balance of trade for selected EST-EGs by development of economy



Source: author calculations based on Comtrade data.

Table 3.5 reports imports, exports and total trade by value in USD of the selected EST-EGs for 2016. Global trade in selected EST-EGs is largely composed of trade flows involving HS 854140 (PV modules, wafers and cells), HS 842139 (filtering or purifying machinery and apparatus for gases) and HS 850300 (parts for electricity generators).

Table 3.6 shows the top-10 importers and exporters in trade of selected EST-EGs over 2006-2016. The US, Germany and Japan were the major importers and exporters in the developed country group. Within the developing country group, China and Mexico were the main traders in the selected EST-EGs. As of 2016, the value of China and Mexico's EST-EG exports is similar to that of the top-3 developed countries (around USD 270 billion). LDCs' contribution to trade of EST-EGs remains limited.

3.6. Relative comparative advantage analysis of trade in selected EST-environmental goods (Category 2)

To gain a better understanding of competitiveness of countries in certain environmental goods, a revealed comparative advantage (RCA) analysis was conducted for the top developed, developing and LDC exporting countries in the top-10 exported EST-EGs with a clear environmental end-use for 2006 and 2016. The comparator group used in calculating the RCA indices is the rest of the world (ROW).

This analysis shows a large number of developed countries exhibiting a revealed comparative advantage in exporting 9 of the top 10 environmental goods with a clear environmental end-use. These countries and products are therefore likely to benefit more from tariff and non-tariff liberalization of EST-EGs, based on existing trade patterns.

All developing countries in our sample, except Russia, exhibit an RCA in exporting one or more of the top-10 exported EST-EGs with a clearer environmental end-use. Two of the top-10 exported EST-EGs – wind towers and lattice masts (HS 730820) and PV module, wafers, cells (HS 854140) - show a greater number of developing country exporters exhibiting a revealed comparative advantage in exporting.

Detailed information about the analysis can be found in Annex 4.

Table 3.5 Total trade, imports and exports of top-10 selected EST-EGs, 2016 (USD billion)

Rank	HS-6 Code	End-use	Total
		Imported	
1	854140	PV module, wafers, cells	50.45
2	842139	Filtering or purifying machinery and apparatus for gases	18.49
3	850300	Parts for electricity generators	16.06
4	842129	Filtering or purifying machinery and apparatus for liquids	7.34
5	842121	Filtering or purifying machinery and apparatus for water	6.59
6	850231	Electricity generation from a renewable resource (wind).	5.30
7	730820	Towers and lattice masts	2.76
8	841790	Industrial or laboratory furnaces and ovens	1.68
9	841919	Solar water heaters	1.53
10	851410	Waste incinerators or other (heat) waste treatment apparatus	1.50
		Exported	
1	854140	PV module, wafers, cells	45.16
2	842139	Filtering or purifying machinery and apparatus for gases	19.07
3	850300	Parts for electricity generators	15.76
4	842129	Filtering or purifying machinery and apparatus for liquids	7.87
5	850231	Electricity generation from a renewable resource (wind).	7.46
6	842121	Filtering or purifying machinery and apparatus for water	6.97
7	730820	Towers and lattice masts	3.07
8	841790	Industrial or laboratory furnaces and ovens	1.90
9	841919	Solar water heaters	1.55
10	851410	Waste incinerators or other (heat) waste treatment apparatus	1.45
		Traded	
1	854140	PV module, wafers, cells	95.61
2	842139	Filtering or purifying machinery and apparatus for gases	37.55
3	850300	Parts for electricity generators	31.82
4	842129	Filtering or purifying machinery and apparatus for liquids	15.21
5	842121	Filtering or purifying machinery and apparatus for water	13.56
6	850231	Electricity generation from a renewable resource (wind).	12.75
7	730820	Towers and lattice masts	5.83
8	841790	Industrial or laboratory furnaces and ovens	3.58
9	841919	Solar water heaters	3.09
10	851410	Waste incinerators or other (heat) waste treatment apparatus	2.95

Table 3.6 Top-10 importers and exporters in trade of selected EST-EGs between 2006 and 2016 (USD billions)

Rank	Importer	Total	Exporters	Total
Developed				
1	USA	152.2	Germany	176.0
2	Germany	138.6	USA	102.3
3	Japan	55.9	Japan	90.5
4	Italy	52.5	Denmark	42.9
5	Korea	37.9	Korea	41.8
6	UK	37.7	Italy	38.7
7	France	37.6	Spain	35.5
8	Spain	37.2	France	29.7
9	Canada	31.8	UK	27.4
10	Netherlands	22.6	Netherlands	21.7

Rank	Importer	Total	Exporters	Total
Developing				
1	China	124.2	China	242.0
2	Mexico	38.1	Mexico	29.9
3	India	22.3	Malaysia	29.1
4	Turkey	17.3	South Africa	26.0
5	Russia	17.2	India	12.8
6	Malaysia	14.4	Brazil	8.2
7	Thailand	13.3	Philippines	8.0
8	Brazil	12.8	Thailand	7.4
9	Viet Nam	8.1	Turkey	5.5
10	Romania	8.0	Viet Nam	4.3

Table continues over page

Table 3.6 Top-10 importers and exporters in trade of selected EST-EGs between 2006 and 2016 (USD millions) (continued)

Rank	Importer	Total	Exporters	Total
		LDCs		
1	Ethiopia	2.170	New Caledonia	0.033
2	Tanzania	0.588	Senegal	0.020
3	Uganda	0.514	Uganda	0.020
4	Mozambique	0.347	Ethiopia	0.018
5	Nepal	0.333	Tanzania	0.007
6	Senegal	0.312	Mozambique	0.007
7	Burkina Faso	0.281	Benin	0.005
8	Zimbabwe	0.238	Mali	0.004
9	Madagascar	0.226	Madagascar	0.003
10	New Caledonia	0.222	Guinea	0.003

Note: **Total value of trade is calculated as the sum of exports and imports.**

3.7. Intra-industry trade analysis of trade in selected EST-environmental goods (Category 2)

The intra-industry trade (IIT) analysis shows that all developed country traders in the sample exhibit large values of the IIT index across the top-10 traded EST-EGs with a clearer environmental end-use. This suggests the prevalence of value-chain-type trade with ROW in these products by all major developed country traders.

All developing country traders, except Indonesia, exhibit large values of the IIT index across the top-10 traded EST-EGs with a clearer environmental end-use. This indicates a prevalence of value-chain-type trade with ROW in these products by the major developing country traders, across more products in 2016 (relative to 2006) for four countries (India, Mexico, Thailand and Turkey) and across more products in 2006 (compared to 2016) for three countries (Brazil, Malaysia and Russia). India, in particular, shows large values of the IIT index for seven of the top-10 traded EST-EGs in 2016. Moreover, four of the top-10 traded EST-EGs – HS 842121, HS 842139, HS 850300 and HS 854140 - show a marked prevalence of value-chain-type trade with ROW for most of the major developing country traders. These countries and products are therefore likely to benefit the most from regional and global value chain integration emanating from the liberalization of EST-EGs.

Only three LDC traders - Benin, Mozambique and Zimbabwe - exhibit large values of the IIT index, but for only four of the top-10 traded EST-EGs with a clearer environmental end-use. This suggests the absence of value-chain-type trade with ROW in most of these products by LDCs. In fact, only one of the top-10 traded EST-EG – HS 841919 - shows some prevalence of value-chain-type trade with ROW for two of the major LDC trading countries. This points to the potential for integrating these countries into regional and global value chains in these products via EST-EGs-liberalization.

More detailed information about this analysis could be found in Annex 5.

3.8. Trade of selected EST-environmental services

3.8.1. Growing attention on environmental services

Environmental services are closely related to, and in many cases, integrated with environmental goods. So far, much of the discussion on trade of ESTs has focused on goods rather than the services. With the emergence of global value chains however, there is a growing focus on environmental services.

3.8.2. Classification

There are three major classification systems for environmental services, referred to as the WTO Services Sectorial Classification List (Table 3.7, Column A); the Eurostat list (Table 3.7, Column B); and the OECD list (Table 3.7, Column C). This, however, refers to the environmental services cluster as a whole, not a classification for each environment-related service specifically.

Table 3.8 shows a comparison between the WTO list (MTN.GNS/W/120 Classification) and the classification of the Pollution Management Group of the OECD/EUROSTAT. Many have voiced concern that the classification is too narrowly and inconsistently defined, but despite alternative submissions, no agreement has been made on a revised version (Bucher et al., 2014).

Table 3.7 Environmental services-lists and classifications across institutions

	A: WTO – Environmental services	B: Eurostat – Environmental goods and services	C: OECD – Environmental goods and services
Classification	1. Sewerage services 2. Refuse disposal services 3. Sanitation and similar services 4. Other (cleaning services for exhaust gases, noise abatement services, nature and landscape protection, and other environment services not elsewhere classified).	**Environmental protection** 1. Protection of ambient air and climate 2. Wastewater management 3. Waste management 4. Protection and remediation of soil, groundwater and surface water 5. Noise and vibration abatement 6. Protection of biodiversity and landscape 7. Protection against radiation 8. Research and development 9. Other environmental protection activities **Resource management** 10. Management of waters 11. Management of forest resources 11 A. Management of forest areas 11 B. Minimisation of the intake of forest resources 12. Management of wild flora and fauna 13. Management of energy resources 13 A. Production of energy from renewable sources 13 B. Heat/energy saving and management 13 C. Minimisation of the intake of fossil resources as raw material for uses other than energy production 14. Management of minerals 15. Research and development 16. Other natural resource management activities	**A. Pollution management** 1. Air pollution control 2. Wastewater management 3. Solid waste management 4. Remediation and clean up 5. Noise and vibration abatement 6. Environmental monitoring, analysis and assessment **B. Cleaner technologies and products** 1. Cleaner/resource efficient technologies and processes 2. Cleaner/resource efficient products **C. Resources management** 1. Indoor air pollution 2. Water Supply 3. Recycled materials 4. Renewable energy plant 5. Heat/energy savings and management 6. Sustainable agriculture and fisheries 7. Sustainable forestry 8. Natural risk management 9. Eco-tourism 10. Other
Status	Conceived in 1991 during the Uruguay Round as a basis for negotiations. Many submissions have been discussed but no new classification agreed.	Published in 2009 for purposes of harmonized data collection for members of the EU. Replaces the OECD/ Eurostat manual of 1999.	List conceived primarily for conceptual or analytical purposes rather than for the purposes of negotiations.

Source: **Bucher et al. (2014)**

Table 3.8 Environmental services: A preliminary comparison between the MTN.GNS/W/120 Classification and the Pollution Management Group of the OECD/EUROSTAT Classification

MTN.GNS/W/120 classification (with the "other" category elaborated using the CPC)	OECD/Eurostat Manual classifications Pollution management Group
A. Sewage services (CPC 9401)	**Waste water management**
Sewage removal, treatment and disposal services Excludes collection, purification and distribution services of water (in CPC 18000) Excludes construction, repair and alteration of sewers (in CPC 51330) (GATS 3B civil engineering construction services)	Design, operation of systems or provision of other services for the collection, treatment and transport of waste water and cooling water. It includes design, management or other services for sewage treatment systems, waste water reuse systems, water handling systems
B. Refuse disposal services (CPC 9402) **C.Sanitation & similar services (CPC 9403)**	**Solid waste management**
Refuse disposal services: Refuse collection and disposal services; collection services of garbage, trash rubbish and waste (household, commercial and industrial); transport services and disposal services; waste reduction services. Excludes dealing and wholesale in waste and scrap (in CPC 62118 and 62278; GATS 4 distribution services) Excludes R&D services on environment issues (CPC 85; GATS 1C Business services (R&D)) **Sanitation and similar services:** Sanitation and similar services including outdoor sweeping, snow and ice clearing. Excludes disinfecting/exterminating services for buildings (in CPC 87401; GATS (1F)(o) – Other Business Building Cleaning Services.) Excludes pest control for agriculture (CPC 88110; GATS 1F (f) services incidental to agriculture, hunting and forestry.	Design, operation of systems or provision of other services for the collection, treatment, management, transport, storage and recovery of hazardous and non-hazardous solid waste. It includes design, management or other services for waste handling (including collection of waste and scrap), operation of recycling plants. It includes services for outdoor sweeping and watering of streets, paths, parking lots, etc. Services for treatment of low level nuclear waste are included. Excludes high level nuclear waste. Excludes services for manufacture of new materials or products from recovered waste or scrap and subsequent use of these materials or products.
D. Other services **Cleaning services of exhaust gases (CPC 9404)**	**Air pollution control**
Emission monitoring and control services of pollutants into the air, whether from mobile or stationary sources; concentration monitoring, control and reduction services of pollutants in ambient air.	Design, managing systems or providing other services for treatment and/or removal of exhaust gases and particulate matter from both stationary and mobile sources
Noise abatements services (CPC 9405)	**Noise and vibration abatement**
Noise pollution monitoring, control and abatement services, e.g. traffic-related noise abatement in urban areas.	Design, managing systems or providing other services to reduce or eliminate the emission of noise and vibration both at source and dispersed. Includes designing, management or other services for acoustic and sound-proof screens and street covering.

Table continues over page

Table 3.8 Environmental services: A preliminary comparison between the MTN.GNS/W/120 Classification and the Pollution Management Group of the OECD/EUROSTAT Classification (continued)

Nature and landscape protection services (CPC 9406) Ecological system protection services, e.g. of lakes, coastlines and coastal waters, dry land, etc. including their respective fauna, flora and habitats. Services consisting in studies on the interrelationship between environment and climate (e.g. greenhouse effect), including natural disaster assessment and abatement services. Landscape protection services n.e.c. Excludes forest and damage assessment and abatement services (in CPC 881, GATS 1F(f). Services incidental to agriculture, hunting and foresting) **Other environmental protection services n.e.c. (CPC 9409)** E.g. acidifying deposition ("acid rain"), monitoring, controlling and damage assessment services	**Remediation and clean-up of soil, surface water and groundwater.** Design, operation of systems or provision of other services to reduce the quantity of polluting materials in soil and water, including surface water, groundwater and sea water. Includes cleaning-up systems either in situ or in appropriate installations, emergency response and spills cleanup systems. Treatment of water and dredging residues are included. **Analytical services, data collection, analysis and assessment** Design, manage systems or provision of other services to sample, measure, and record various characteristics of environmental media. Includes monitoring sites, both operating singly and in networks, and covering one or more environmental medium. Health, safety, toxicology studies, and analytical laboratory services are included. Weather stations are excluded.
[Business Services – R&D natural sciences and engineering; CPC 85] as well as **Environmental Services – Other Services, CPC 9406, 9409**	**Environmental R&D** Any systematic and creative activity which is concerned with the generation, advancement, dissemination and application of scientific and technological knowledge to reduce or eliminate emissions in all environmental media and to improve environmental quality. Includes creative scientific and technological activities for the development of cleaner products, processes and technologies. It includes non-technological research to improve knowledge of eco-systems and the impact of human activities on the environment.
[Construction and related engineering services (CPC 51330)]	Services related to activities for the construction and installation of facilities for: air pollution control; waste water management; solid waste management; remediation and cleanup of soil, water and groundwater; noise and vibration abatement; environmental monitoring; analysis and assessment; other environmental facilities.
Other environmental protection services, CPC 9409; possibly also [5 – Educational Services – Other]	**Education, training, information** Provision of environmental education or training or dissemination of environmental information and which is executed by specialised institutions or specialised suppliers. Includes education, training, and information management for the general public, and specific environmental work place education and training. The activties of the general educational system are excluded.

Source: Environmental Services - S/C/W/46, Background Note by the Secretariat, WTO 1998.

3.8.3. Data limitation

Given the lack of a detailed classification that is supported by statistics institutions, and the significant disagreement on the current classifications, many countries and databases do not provide comparable cross-country data of environmental services. For instance, in the UN Comtrade database, there is data on "waste treatment and de-pollution services" for 22 countries in 2005 and eleven countries in 2010, while in the WTO database, data on EST-ESs is classified as "waste treatment and de-pollution, agricultural and mining services" for 25 countries in 2010 and "waste treatment and de-pollution" for 32 countries in 2015. Although substantial improvements have been made to quantify restrictions to trade in EST-ESs, the data remain problematic for cross-country comparisons, even for measuring services trade itself. This issue is particularly serious for the environmental services analysis in this study, constraining the ability of researchers to conduct empirical analysis of EST-ES trade.

A number of national and international statistics institutions, however, have already engaged in the collection of relevant data. For example, Eurostat has started to provide information on the EST-EGs and EST-ESs trade for EU countries and a few other countries, and steps were recently taken to go further. There is also a need for more information at the firm-level, so as to better account for the broader set of services that feed into environmental projects. More data would allow for more quantitative analysis and better data would help to build up a comprehensive picture of trade in environment-related services, and therefore provide governments, policymakers, and stakeholders with accurate messages when investing in EST-ESs. More importantly, the lack of clear definitions cannot facilitate robust and reliable data collection and comparisons over time.

3.8.4. Trade patterns in selected EST-environmental services

Due to the presented data availability issues, the following analysis is restricted in the number of countries taken into account and focused on trade in waste treatment and de-pollution, agricultural and mining services in the case of seven countries and waste treatment and de-pollution services for the remaining 26 countries. The analysis is based on WTO and UN Comtrade data.

As shown in Figure 3.13, over the past decade, global trade of selected EST-ESs[39] has multiplied, rising from over USD 5.7 billion worth of total trade in 2006 to more than USD 41.5 billion in 2014, when it reached its peak, and falling back to USD 29.0 billion in 2016.

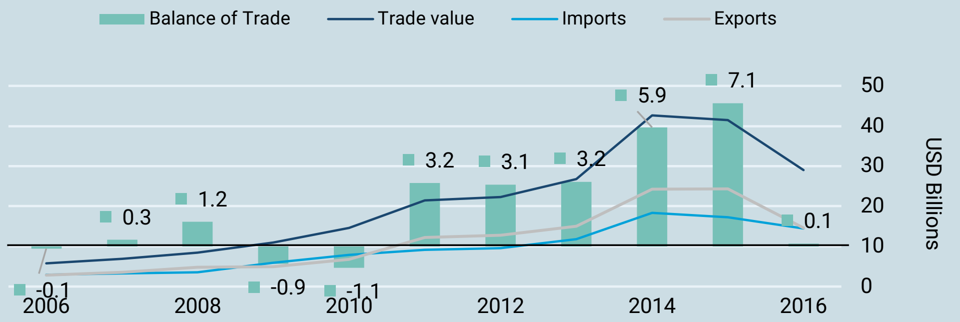
Table 3.9 reports the leading countries in trade of selected EST-ESs in terms of total trade, imports and exports. The top three regional destinations of global exports of waste treatment and de-pollution services[40] between 2006 and 2016 were Russia (USD 24.7 billion), France (USD 20.4 billion) and the US (USD 14.9 billion). On the exports side, the US (USD 33.6 billion) and France (USD 1.3 billion) are leading exporters of the selected EST-ESs. In both the import and the export lists, the EU countries play an important role.

Footnotes

39. For the countries Australia, Austria, Colombia, Iceland, Russia, UK, and US, data of waste treatment and de-pollution, agricultural and mining services is used; for the rest of countries, data of waste treatment and de-pollution is used.

40. For countries, Australia, Austria, Colombia, Iceland, Russia, UK, and US, data of waste treatment and de-pollution, agricultural and mining services is used.

Figure 3.13 World trade of selected EST-ESs



Note: This figure presents trade in selected EST-ESs for the following countries: Australia, Austria, Belgium, Bulgaria, Canada, Colombia, Croatia, Cyprus, Czech, Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Portugal, Romania, Russian, Slovak Republic, UK and USA. For countries, Australia, Austria, Colombia, Iceland, Russia, UK, and US, data of waste treatment and de-pollution, agricultural and mining services is used; for the rest of countries, data of waste treatment and de-pollution is used. Note: Total value of trade is calculated as the sum of exports and imports.
Source: author calculations based on Comtrade data.

Table 3.9 Leading traders, importers and exporters of selected EST-ESs over 2006-2016 (USD billion)

Rank	Traders		Importers		Exporters	
1	France	51.7	Russia	24.7	USA	33.6
2	USA	48.5	France	20.4	France	31.3
3	Russia	32.0	USA	14.9	Netherlands	19.8
4	Netherlands	28.2	Colombia	9.2	UK	12.0
5	UK	15.1	Netherlands	8.3	Russia	7.3
6	Colombia	11.3	Australia	4.6	Italy	2.8
7	Australia	7.4	Italy	4.0	Australia	2.8
8	Italy	6.8	Canada	3.8	Belgium	2.8
9	Canada	6.2	Denmark	3.3	Germany	2.6
10	Belgium	5.0	UK	3.1	Canada	2.4

Note: **Above figure presents trade flows of the following countries: Australia, Austria, Belgium, Bulgaria, Canada, Colombia, Croatia, Cyprus, Czech, Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Portugal, Romania, Russian, Slovak Republic, UK and USA. For countries, Australia, Austria, Colombia, Iceland, Russia, UK, and US, data of waste treatment and de-pollution, agricultural and mining services is used; for the rest of countries, data of waste treatment and de-pollution is used. Note: Total value of trade is calculated as the sum of exports and imports.**

Source: **Author calculations based on WTO and Comtrade data**

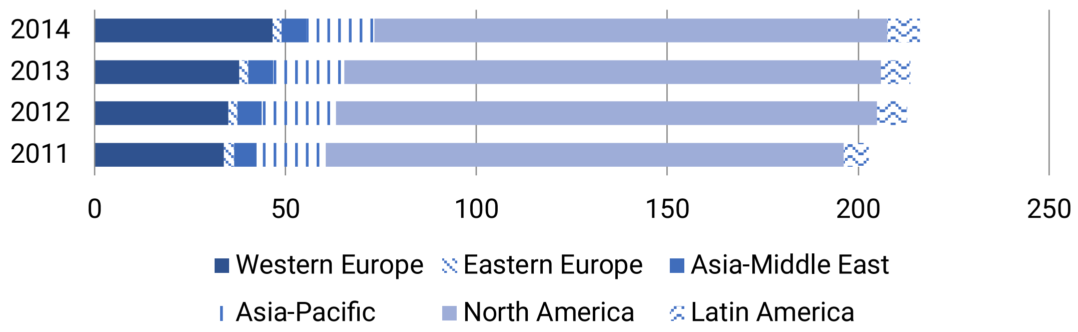
3.8.5. Trade patterns in selected EST-environmental services in the private sector

This study obtained a dataset of 61 companies, whose combined revenue amounts to about 40% of the global market of environmental consultancy and engineering services (ES-CEs), in order to show the trend of EST-ES-CEs in the private sector companies (cf. Sauvage and Timiliotis, 2017).

Table 3.10 reports the country breakdown of the 61 firms. The US firms are core suppliers of global ES-CEs (USD 480.1 billion as shown in Table 3.11). This may be partly due to the predominance of US multinational enterprises in this sector and intensive exchanges within their networks of operating subsidiaries. Indeed, the US exported the largest part of global waste treatment and de-pollution, agricultural and mining services (see Table 3.9). While the presence of firms located in developing countries is limited in the sample, the analysis aims to provide insights into the trends in the private sector as a basis for further analysis once more data is available.

The regional distribution of ES-CEs revenue for countries is shown in Table 3.11. The US has the highest total revenue and is leading by far. US firms deliver 82.5% of their services in North America and only generate minor revenues in other regions. The UK is ranked in the 5th place and is the country providing the fourth-largest supply of ES-CEs to North America (51.9%), rather than the West EU (29.9%). This suggests a diversified structure of targeted markets. Japan and Germany, as two of top-3 EST-EGs exporting countries, ranked at the bottom of the list and served a single market. East EU and Latin America are the markets least attractive to 61 ES-CEs supplying firms. Figure 3.14 shows the trend of revenue in different regions between 2011 and 2014. There is a clear increasing trend in revenue of ES-CEs across all regions.

Figure 3.14 Total revenue of ES-CEs for the 61 firms by region, 2011-2014 (USD billion)



Source: **Sauvage, J. and C. Timiliotis (2017), "Trade in services related to the environment", OECD Trade and Environment Working Papers, 2017/02, OECD Publishing, Paris.**

Table 3.10 Distribution of the 61 firms by country

Country of origin	Frequency	Percentage
Australia	6	9.8
Belgium	1	1.6
Canada	7	11.5
Denmark	1	1.6
Finland	1	1.6
Germany	1	1.6
Japan	2	3.3
Malaysia	1	1.6
Netherlands	4	6.6
Spain	1	1.6
UK	6	9.8
US	30	49.2
Total	**61**	**100.0**

Table 3.11 Total revenue and shares of ES-CEs for top-61 firms by country and region over 2011-2014

Rank	Country	ES-CEs (USD billion)	West EU	East EU	Asia-Middle East	Asia-Pacific	North America	Latin America
1	US	480.1	6.4%	0.8%	2.2%	5.9%	82.5%	2.1%
2	Canada	97.0	9.4%	0.4%	4.1%	9.2%	72.5%	5.1%
3	Netherlands	81.1	48.9%	3.7%	6.5%	5.0%	29.5%	6.3%
4	Belgium	60.3	80.0%	2.0%	2.0%	3.0%	0.0%	13.0%
5	UK	52.0	29.9%	1.8%	4.4%	10.8%	51.9%	1.2%
6	Australia	47.6	7.2%	0.2%	3.1%	36.2%	49.7%	3.6%
7	Denmark	12.0	36.4%	2.5%	0.4%	5.5%	53.6%	1.6%
8	Japan	5.8	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
9	Germany	0.7	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	Spain	0.4	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%

4. Opportunities and challenges of EST trade liberalization I: Economic and social impact analysis

The previous chapter provided a set of statistics on the main importers and exporters of ESTs across the last decade, pointing to the dominant role of developed countries along with a growing presence of developing countries led mostly by China. In this chapter, the benefits and challenges of boosting trade in ESTs are discussed. This is done with a focus on developing countries and the potential implications that reducing barriers to trade in ESTs would have in terms of their sustainable development.

A large number of academic and policy literature has analysed and evaluated the economic, social, and environmental benefits and challenges connected to the liberalization of trade in ESTs. Yet, although scholars agree on the urgency to facilitate and scale up the diffusion of ESTs, there is no consensus over the means to achieve this goal. On the one hand, some point to the importance of liberalizing trade and fostering international cooperation while preventing "mercantilist" approaches and reducing the cost of trade litigations. On the other, critics question the impact of liberalization policies on less advanced economies, particularly regarding their environmental and social consequences. Furthermore, as observed in previous Chapters, the exact definition of ESTs remains disputed and, as the WTO negotiations demonstrate, countries face disagreements stemming from their respective economic and commercial interests – with a clear division between developed and developing countries (Khatun, 2012; Balineau and De Melo, 2013; Wu, 2014).

Literature suggests that due to its urgency and potential for unfair social outcomes, the question of reducing tariffs for ESTs should be distinguished from the traditional debate on trade liberalization. In this respect, while overall market liberalization is often associated with environmental degradation via increased production, measures aimed at favouring trade in ESTs have the potential to provide a win-win situation and achieve growth that does not deplete environmental resources. In fact, scholars have warned against the limitations and challenges that liberalizing trade in ESTs entails. Accordingly, several studies point to the further need for green industrial policy to overcome non-tariff barriers and generate a market for ESTs, especially in developing countries where a lack of capabilities and purchasing power represents a major constraint to market participation.

4.1. Barriers to trade in ESTs and market liberalization

The need to overcome tariff and non-tariff barriers to favour trade in ESTs has been reiterated in Paragraph 31 of the 2001 Doha Ministerial Declaration, agreeing to negotiations on 'the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services'. This section discusses the need for international cooperation and the scope for including non-tariff barrierss in any future deal regulating trade in ESTs.

- *Tariff barriers* constitute a widely-used tool of industrial policy to protect infant industries and boost industrialization and growth. They imply the voluntary imposition of a duty on the import and/or export of specific goods, usually identified under national tariff-lines (these can be, in some cases, harmonized within regional cooperation agreements). By definition, tariffs involve a payment which can be assessed as an absolute amount or as a percentage of the exported/imported value. They constitute a source of revenue for governments and are therefore different from subsidies, performance requirements, and other carrots and sticks used to support specific sectors in the economy.

- *Non-tariff barriers* have been defined by UNCTAD (2012) as policy measures other than ordinary custom tariffs that can potentially have an economic effect on the quantity and/or price of internationally traded goods and services. UNCTAD further presents a taxonomy based on technical and non-technical issues, and export-related measures. Technical measures include: sanitary and phytosanitary measures, technical barriers to trade,[41] and pre-shipment inspections. Non-technical barriers refer instead to: contingent trade-protective measures (e.g. anti-dumping and safeguard measures to counteract the adverse effect of imports for local firms), non-automatic quotas and price control measures, finance measures to restrict the payments of imports or the terms of payment, measures affecting competition (e.g. granting privileged treatment to specific firms), trade-related investment measures (e.g. local content requirements), restrictions on distributions and post-sales services, subsidies (excluding export-subsidies), public procurement restrictions, intellectual property regulations, and rules of origins. Finally, export-related measures include export-related taxes, compensations schemes, quotas, and prohibitions.

Similarly, the WTO (2018) classifies non-tariff barriers under five categories related to import licensing, rules for the valuation of goods at customs (e.g. packaging and documentation requirements and other product and process standards), pre-shipment inspections (e.g. price, quantity, and quality controls), rules of origins (e.g. quotas, preferential tariffs, anti-dumping actions, and countervailing duty), and investment measures (e.g. local-content and trade balancing requirements, public procurement policies, and restrictions on investment and ownership).

Footnotes

41. *Technical barriers to trade* **is a concept used to indicate the use of product standards and certification requirements beyond those made mandatory under the WTO Agreement on the Application of Sanitary and Phytosanitary measures to screen local industries from foreign competitors (UNCTAD, 2012).**

It is important to note that non-tariff barriers are not always and necessarily a policy tool. Instead, they can also emerge incidentally to prevent or slow down trade relations. This is the case of inefficiencies in custom services and other related offices, political and macroeconomic instability, rule of law, inadequate communication and transportation infrastructures, weak financial sectors, and lack of educated workforce. In this respect, non-tariff barriers that are specific to ESTs comprise, among others, a lack of guidance on environmental policy, monopolistic structures with low fiscal and incentives for incoming producers, fossil fuel subsidies linked to welfare considerations, and weak environmental regulations and enforcement capacity (Cosbey, 2008; Zhang, 2013; Hammeren, 2014; Monkelbaan, 2017).

International cooperation in this domain has been characterized by a widespread consensus over the need for a fast- and internationally-coordinated effort to tackle environmental degradation while avoiding mercantilist approaches that downsize the impact of environmental externalities (Roberts and Thanos, 2003; Less and McMillan, 2005). Nevertheless, the use of trade liberalization as a tool to achieve this objective vis-a-vis an increasing adoption of trade defence measures has led to a growing number of international disputes (Cosbey, 2017).

For instance, the recent decision of the US government to impose a 30% tariff on the import of solar cells and panels in early 2018 followed a lengthy debate over the unfair use of industrial policy by foreign economies to boost their exports whilst limiting imports (Shen and Fu, 2014; Lee, Park and Saravia, 2017). Specifically, the US accused China, the world's leading manufacturer of solar panels, of dumping practices, subsidizing exports, favouring technology appropriation through lax property rights, while allowing preferential treatment to local firms – a use of green industrial policy labelled as "green mercantilism" (Stepp and Atkinson, 2012). Moreover, antidumping cases and accusations of unfair competition in the renewable energy sector have increased in the last decade, especially as developed economies witnessed an erosion of their market share. Even though most cases were filed by the US, the EU, and Japan, in 2016 the Indian Solar Manufacturers Association initiated an anti-dumping investigation against the imports of solar cells from China, Chinese Taipei and Malaysia. Similarly, China accused polysilicon suppliers from the US and the EU of dumping, while the Republic of Korea recently initiated a dispute settlement process at the WTO protesting the 2018 US introduction of tariffs on solar panels (Rubini, 2012; Monkelbaan, 2017; Reuters, 2018).

Between 2006 and 2015, the WTO was notified with 45 trade remedy cases in the clean energy sector alone, accounting for estimated costs of USD 32 billion worth of trade in green products between 2008 and 2012 – about 4% of the global trade in the sector (Kampel, 2017). Legal battles are not confined to inter-state trade relations, but they further affect intra-national and regional policy debates. For instance, Kommers (2014b) analyses the conflictual nature of EU trade and climate policy, with the first's goal to increase consumption of renewable energy, undermined by protectionist trade measures raising the price of imported renewables. As stressed by Lewis (2014b), these disputes point to an inherent conflict between the political economy of national governments and the basic principles of free trade. The main argument against green industrial policy is that subsidies and many other measures of state intervention limit and distort competition and prevent the innovation required to reduce production costs below those of brown technologies (Stepp and Atkinson, 2012; Kampel, 2017). Nevertheless, as argued in this chapter, such an approach not only downsizes the urgency related to climate change but, given the current institutional framework, it is likely to escalate interstate tensions which would limit rather than increase the diffusion and adoption of ESTs. In particular, with regard to the question of access to technologies, intellectual property rights associated with ESTs constitute a major aspect of contention between developed and developing countries. Overall, recent trade and climate change negotiations have been divisive: while developed countries favour a market-based system which protects intellectual property rights, developing countries call for a mechanism of direct grants and limited restrictions on intellectual property rights to overcome the rigidity of a monopolistic market structure (Morsink, Hofman and Lovett, 2011; Correa, 2013; Oh, 2017). In this respect, scholars also disagree, with proponents of intellectual property rights stressing the latter's role in facilitating foreign investments and technology transfer (Less and McMillan, 2005; Ambec, 2017) and critics pointing to how intellectual property rights regimes deter innovation and slow down industrialization of developing countries (Boldrin and Levine, 2013; Correa, 2013).

Due to the urgency associated with preventing further environmental degradation and the need to avoid costly disputes, scholars have argued in favour of international cooperation to facilitate technology and innovation transfer. Proposals in this regard include the formation of bilateral R&D cooperation based on the model of the US-China Clean Energy Research Center (CERC) (Lewis, 2014a), the creation of a shared 'repository fund' of patents addressing critical sectors such as health and climate change (Mytelka, 2007), a legal reform of the WTO to reduce the costs of litigations and allow for specific forms of green industrial policy with positive environmental externalities (Cottier, 2011; Rubini, 2012; Cosbey, 2017), the reinforcement of technology transfer mechanisms such as the Green Climate Fund established by the United Nations Framework Convention on Climate Change (UNFCCC) in 2010 (Lewis, 2014b), and a more radical regional and/or global reform to eliminate trade remedies in clean energies including WTO-plus provisions (Meléndez-Ortiz, 2016; Kampel, 2017). Moreover, the success of open-source schemes has been indicated as a potential platform to share ESTs and increase their diffusion in developing countries (Correa, 2013).

Overall, there is a general consensus that any agreement on the liberalization of trade in ESTs should shelter its participants from negative economic and social consequences (UNEP, 2013). For this to happen, as the debate on the role of green industrial policy and intellectual property rights proves, negotiations cannot avoid a larger discussion concerning the role and function of non-tariff barriers.

Non-tariff barriers to trade in environmentally sound technologies

Although Paragraph 31 of the 2001 Doha Ministerial Declaration acknowledges the importance to overcome non-tariff barriers, this aspect remains mostly untapped in the negotiations that led to the APEC agreement and the ongoing WTO EGA process (Vikhlyaev, 2011; Vossenaar, 2013; Wu, 2014).

On the one hand, scholars have pointed to the limitations that non-tariff barriers impose on the diffusion of ESTs, particularly in developing countries where their negative impact on trade is significant. For instance, according to Wooders (2009), tariff removal without addressing non-tariff barriers would have a very modest impact on the increasing usage of renewable energy with no more than 0.1 to 0.9% reduction in greenhouse gas emissions by 2030.[42] Similarly, analysing the relationship between the liberalization of trade in ESTs and bilateral exports of environmental goods, He et al. (2015) point to the low impact that this has for net importers compared to non-tariff barriers whose effect in restricting environmental goods imports is significantly more important.

On the other hand, as observed in the previous paragraphs, while representing a challenge to market access, some non-tariff barriers can be voluntarily used by governments as effective tools of green industrial policy (UNEP, 2011). According to Less and McMillan (2005), market forces may encourage pollution. Whilst lower tariffs on environmental goods reduce prices and increase accessibility, the diffusion of ESTs further requires public intervention through public 'seed' funds to initiate EST-related R&D and support technology transfer. This is particularly the case in countries whose exports are concentrated on polluting resources: as of 2015, mining and fossil fuels constituted over 60% of the exports of 10 and 16 countries respectively, while 25 countries relied on

Footnotes

42. A result that can be partially contested as the mean cost of electricity for utility-scale solar fell by 72% from USD 178 per megawatt-hour (MWh) in 2009 to USD 50/MWh in 2017, and 47% from USD 85/MWh to USD 45/MWh for wind energy over the same period (Marcacci, 2018).

commodities' exports for another 60% of their market share (UNFCCC, 2016, pp. 8–10). In this respect, state measures aimed at diversifying the economy away from brown sectors and ensuring adherence to internationally endorsed environmental rules are, according to several scholars, a necessary tool of 'pathway disruption' (Altenburg and Pegels, 2012; Cosbey et al., 2017; UNCTAD, 2018).

Although the adoption of payment for ecosystem services represents a first step in this direction, and one whose positive environmental and social impact is widely corroborated (Pagiola, Arcenas and Platais, 2005; Engel, Pagiola and Wunder, 2008; Rival and Muradian, 2013; Jayachandran et al., 2017), price-related instruments to address environmental externalities are often considered insufficient.[43] According to Lüktenhorst et al. (2014) and Cosbey et al. (2017), full-cost pricing is not enough to address market failures such as the uncertainty about pricing reforms, financial constraints, incomplete market information, and inadequate appropriability of R&D investments. Complementary policies are required to help phase-in green technologies while at the same time phase out polluting ones. Never and Kemp (2017) provide a roadmap for phase-in policies that draws on the successful experiences of India, China, Germany, and the Netherlands. This is presented in Table 4.1 and it encompasses a set of measures whose role is instrumental to broadening the diffusion of ESTs. Although the work on green industrial policy rarely engages with the literature on global value chains and firms' upgrading, most of the recommendations in Table 4.1 could be understood as a way to favour economic and social upgrading through horizontal and vertical governance involving private actors (i.e. lead-firms and suppliers), national and local governments, as well as civil society and other interests groups (Gereffi and Lee, 2016).

Green industrial policy, whilst it may involve the use of non-tariff barriers, further addresses a number of social, economic, and environmental externalities through targeted policies which include, but are not limited to infrastructure investments, financial support, industrialization, and training and capacity building (Bazilian and Rentschler, 2016). While liberalizing trade only among the participants of the WTO EGA would certainly increase access to ESTs, lacking the participation of developing countries is likely to have long term negative repercussions (Wu, 2014). Failure to address the non-tariff barriers that prevent investment in ESTs would increase future switching costs for a large number of countries. This is particularly the case for emerging economies, whose lion's share of industrial growth is expected to occur between now and 2030 (Cosbey, 2008). This effort will stem from the need to redirect technology policy towards addressing climate change more directly and enabling developing countries to experiment with sustainable solutions, especially in key areas where they maintain a comparative advantage such as water purification and organic agricultural systems (UNEP, 2014).

Overall, while addressing tariff and non-tariff barriers to trade could throw up challenges, it can potentially open up several opportunities for developing countries to specialize in segments of global value chains for ESTs. The following section discusses such opportunities and challenges in greater detail.

4.2. Opportunities and challenges of liberalizing trade in general

The effect of trade liberalization on the economy of developing countries spans the macro- and microeconomic literature on trade and learning-by-exporting (Goldberg et al, 2010; Rodriguez and Rodrik, 2000; Siba and Gebreeyesus, 2017), scholarship

Footnotes

43. Note that the concept of ecosystem service is different from that of environmental services used in this report, as the latter is delivered by humans as a commercial service whilst the former is linked to an environmental features impacting on biodiversity.

Table 4.1 Roadmap for an effective phase-in policy

Stage	Activity	Responsible bodies
1. Pro-active planning	Development of a long-term vision with interim goals and steps	Government
2. Communication	The vision agenda should be communicated to investors, innovators and other stakeholders at an early stage to identify technologies and innovations and to prepare producers and consumers.	Government and relevant stakeholders (manufacturers, business associations, standardization bodies)
3. Selecting options and forms for support	Which sectors to support and what kind of measures to implement (e.g. subsidies, feed-in tariffs…) should be assessed with the support of external experts to avoid political capturing by lobby groups. Time-bound subsidies schemes may help making support cost-effective.	Government and independent experts
4. Adopt a sequential approach	The tightening of environmental regulations and reduction of abatement costs should be implemented gradually and/or via the testing of pilot projects before scaling up. This is done to further minimize social resistance.	Government, stakeholders, and representatives of civil society
5. Include mechanisms of policy learning	Successful phase-in requires a long time-span with several cycles of adjusting policies. Policy-learning rounds should be planned to evaluate interim goals, identify vested interests and dominating actors, and ensure that economic and social gains are achieved and shared especially with low-income segments.	Government, stakeholders at the central and local levels, and external experts
6. Design a coherent policy package	Ensuring that different regulations are designed to complement and strengthen each other in a coherent policy package with shared targets (e.g. are associated with a plan of financial incentives, R&D, employment creation measures and targets, trust-building measures for stakeholders, standards…). This requires a high degree of collaboration among actors in the policy process to ensure that the capabilities and interests of different actors are considered in the phase-in plans.	Government and private and public stakeholders at different levels of governance
7. Implement adequate control mechanisms	Building and financing of technology testing facilities and the evaluation of implementation schemes. This includes fostering consumers' awareness about ESTs and other knowledge-sharing activities.	Government

Source: author's elaboration based on Never and Kemp (2017)

on innovation, knowledge acquisition, and industrial upgrading (Acemoglu, 2002; Fu, Pietrobelli, and Soete, 2011; J. Lin and Chang, 2009; Sanchez-Ancochea, 2009) and, more recently, research on global value chains and global production networks (Gereffi and Sturgeon, 2013; Staritz, Plank, and Morris, 2016). While proponents of free trade point towards the positive impact of liberalization on economic growth and social welfare (Grossman and Krueger, 1991; Salinas and Aksoy, 2006; Winters, 2004), critics argue for the implementation of "control mechanisms" to prevent information externalities and coordination failures while favouring innovation and industrialization (Amsden, 2001; H.-J. Chang, 2002, 2013; Hausmann and Rodrik, 2003; J. Y. Lin, 2012; Lundvall, 2007; Rodriguez and Rodrik, 2000). An analysis of these two scholarship traditions lies beyond the scope of this chapter, yet a brief overview of their core principles is paramount to understand the ongoing debate over the liberalization of ESTs and its consequences. The main findings are summarized in Table 4.2. A more detailed analysis of economic, social and environmental benefits and challenges of trade liberalization can be found in Annex 7.

4.3. Liberalizing trade in ESTs: the need for a different approach

Despite focusing on economic growth and social welfare, the discussion over the liberalization of trade in environmental goods and the role of green industrial policy revolves around the concept of *green economy* – a situation that improves human well-

Table 4.2 Opportunities and challenges linked to an overall market liberalization

Opportunities	Challenges
Static gains from the re-allocation of resources (E)	Deterioration in the terms of trade of developing countries (E)
Learning-by-exporting: productivity fostered by participation in export markets (E)	Self-selection: firms become efficient before rather than after entering export markets (E)
Participation in global valu chains: Innovation fostered by competition and access to globally dispersed knowledge and technology (E)	With the growth of trade in global value chains, manufacturing has been associated with lower returns due to staggering competition (E)
Increased consumption generated by lower prices and increased access to market (S)	Lower consumption as wages decrease due to increased competition (immiserising growth) (S)
Wages increase as labour productivity and demand increase (S)	Productivity alone does not lead to an increase in workers' remuneration, which is instead the outcome of a bargaining process (S)
Environmental Kuznets Curve hypothesis: negative relationship between income and pollution (EV)	Monotonic relationship between income and pollution (EV)
Reduction in countries' abatement costs by facilitating access to pollution control technologies (EV)	As ESTs are less cost efficient than conventional technologies, free trade will not favour their adoption without further incentives (EV)
Inconsistent evidence supporting the pollution haven hypothesis (EV)	Pollution haven and industrial flight hypotheses predict a transfer of environmental externalities from high- to low-income countries (EV)

Source: **Author's elaboration**

being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEMG, 2011; UNEP, 2013). In this respect, fostering economic, social, and environmental benefits in a way that prevents environmental degradation and enables income growth, employment, and quality of labour, represents the three-pillar strategy of *sustainable development*, one that meets the needs of the present without compromising those of future generations (WCED, 1987; Lehtonen, 2004; UNEP, 2011). To the extent that a green economy implies the adoption of products and processes that favour the abatement of environmental externalities, its rationale retraces the dualism between liberalization and industrial policy as countries strive to achieve competitive advantages in sectors such as renewable energies, sustainable agriculture, waste treatment, and, more generally, technologies and business models that limit environmental pollution (Copeland, 2012; Schwarzer, 2013; Ambec, 2017).

Nevertheless, despite sharing most of its principles, the pursuit of a green agenda demands an independent approach from the one described in the previous section. This is the consequence of two major aspects: *urgency* and *fairness*.

Firstly, the scope and consequences of decoupling growth from environmental degradation are all the more pressing as the cost of a potential failure would bear irreversible consequences (Lütkenhorst et al., 2014; Ripple et al., 2017). This element of urgency emerges from the UNFCCC Paris Agreement on climate change (COP21), ratified by 196 countries and aimed at reducing greenhouse gas emissions and limiting global warming to 2°C above pre-industrial levels (UNEP, 2015c). To achieve this goal, the average decarbonization rate would have to reach 6.3% each year up to 2100, much higher than the modest 2.6% decline achieved in 2016 (PwC, 2017). Reaching this target is all the more challenging if we consider that no country has yet managed to systematically decouple economic welfare and growth from resource consumption (Altenburg and Rodrik, 2017), and almost all major traders in ESTs are still struggling to reach this threshold.[44] Overall, whilst it is acknowledged that such "necessary level of ambition" will require unprecedented social and economic changes within a relatively short time frame (UNCTAD, 2018), it is also true that some countries have done better than others. For instance, in 2016 the UK and China reduced carbon emission by 7.7% and 6.5% respectively, exceeding their Intended Nationally Determined Contributions under the Paris Agreement and the 6.3% global annual decarbonization target (PwC, 2017). It is further recognized that developing countries have the potential to achieve ambitious levels of reductions in CO2 emissions comparable to the West (Stern and Jotzo, 2010). However, to the extent that their polluting industries differ both in kind and factor endowments, decoupling policies cannot follow any standardized procedure. This is further complicated by the diverse context underpinning countries' financial resources and institutional capacities (Never and Kemp, 2017, p. 88).[45] In addition to climate change, environmental degradation is made all the more urgent by air, soil, and water pollution whose detrimental impact is causing the loss of ecosystem services, negatively affecting livelihoods through income losses, water scarcity, and health-related concerns (UNEP, 2011). As further argued in the subsequent sections, this impact is likely to be stronger for developing countries undergoing industrialization. As reported by UN Environment (2011), accounting for 10% of global water demand and 17% of air pollution-related health damages, manufacturing represents a key sector for the future industrial development of

Footnotes

44. Most participants of the WTO EGA, together accounting for 86% of the total trade in ESTs and including the larger emitters of CO2 (Wu, 2014), are still below the target. Moreover, large economies such as India and Brazil whose growing economies are likely to have a considerable impact on the environment in the decades to come are not involved in the negotiations.

45. The UN Environment case studies summarized in Annex 8 provide further evidence of specific country programmes targeted at decoupling environmental degradation from economic growth. An in-detail explanation of the policies implemented by more successful countries is beyond the scope of this

emerging economies and one in which a failure to embark on a green economy transition will generate increasing switching costs.[46]

Secondly, favouring the transition to a green economy departs from the traditional notion of national industrial policy to the extent that a country's short-term economic and social gains may come at the expense of the environment (Altenburg and Rodrik, 2017). For instance, it is estimated that phasing out fossil fuel subsidies, while triggering a considerable decrease of greenhouse gas emissions (Burniaux and Chateau, 2014; Schwanitz et al., 2014), would have a negative impact on developing countries' GDP through a rise in the price of conventional energy and the consequent decrease in output and unemployment of this sector (Jha, 2013).[47] Moreover, while the trade-off between social welfare and environmental protection has been convincingly disputed (UNEP, 2011; Frey, 2016; Padilla, 2017), the expected growth of the world population to 9 billion by 2050 requires a considerable increase in production outputs to ensure food security and poverty reduction (UNEMG, 2011). As upheld by the International Labour Organization (ILO) (2010) principle of Just Transition, the urgency to respond to the environmental challenge cannot distract from its social and economic consequences, especially when these affect vulnerable low-income groups (Jakob et al., 2015; Cosbey et al., 2017). Fairness remains therefore a central aspect, though one that has to be vetted against its environmental impact.

In this respect, the UN Environment (2017) green industrial policy tool-box presents a policy framework to minimize the negative impact that a green growth model could have on employment and social welfare. Moreover, as further argued in Section 4.4, the diffusion of ESTs plays a crucial role in improving labour conditions and particularly those of women, whose proportionally larger participation in activities such as recycling and subsistence agriculture makes them more dependent on threatened natural resources (ILO, 2009; UNEP, 2012a; Monkelbaan, 2017).

Spanning the trade and innovation literature with a focus on environmental sustainability and green industrial policy, the remainder of the chapter provides a comprehensive overview of the benefits and obstacles related to the liberalization of trade in ESTs as way to address environmental degradation and enable a decoupling of the latter from the production process.

4.4. Environmental goods: Opportunities and challenges

Although no final agreement has yet been reached as part of the WTO multilateral as well as plurilateral EGA negotiations, both these as well as discussions on APEC's voluntary agreement have been overly concerned with technology intensive manufactured goods used to address environmental problems – i.e. equipment for renewable energy generation, environmental monitoring and analysis, solid and hazardous waste management, and wastewater management (Vossenaar, 2013; Znamenackova et al., 2014). The next subsections provide an overview of the challenges and opportunities associated with reducing tariffs on environmental goods. Table 4.3 summarizes some of the main outcomes.

4.4.1. Gains from liberalizing trade in environmental goods

Extensive work has been conducted on the impact of liberalizing trade in environmental goods (see Annex 6 for an overview of all sources reviewed) and the 2012 APEC agreement has already achieved a regional, albeit voluntary reduction in tariffs barriers for 54 environmental goods.

Footnotes

46. A similar argument can be made for the constructions sector, presently contributing to about 40% of solid wastes globally (UNEP, 2011).

47. See Section 4.1 for a discussion on the impact of policies aimed at phasing out polluting sectors.

Table 4.3: Opportunities and challenges linked to the liberalization of trade in environmental goods

Opportunities	Challenges
Reducing environmental degradation by increasing access to competitively priced environmental goods (EV)	The increase in demand will partly offset potential environmental benefits (scale effect) (EV)
Stimulating manufacturing by increasing competition and expanding nascent green markets and industries – as opportunities accrue from ESTs and innovation diffusion (E)	Increased competition leading to lower profits in countries where applied import tariffs are higher and trade costs elasticities more pronounced (E)
Gains from trade would be greater for developing countries whose initial tariffs and price elasticities tend to be higher (E, S)	Gains from trade would accrue mostly for developed countries with an initial comparative advantage, as their imports would grow relatively less than their exports (E, S)
Employment opportunities are created in developing countries, especially considering the labour-intensiveness characterizing several environmental goods and the potential for job-creation in the downstream provision of services and components (S)	LDCs do not import environmental goods due to a lack of capabilities and purchasing power. Tariffs reduction has little effect unless it is carried out along with measures aimed at market creation (E)
Lower prices lead to increased consumption of environmental goods and products that use them as inputs, further increasing environmental goods competitiveness vis-a-vis polluting technologies (E, S)	Risk that pollution taxes in importing countries are reduced to compensate for the rents lost through liberalization, which have now been transferred to the foreign eco-industry (E, P)
Providing new opportunities to upgrade polluting sectors and assimilate them in the green economy - i.e. circular economies (E, EV)	Some environmental goods utilize components whose production constitutes an environmental hazard. This is particularly relevant to developing countries participating in upstream stages of ESTs value chains (EV)
Dual-use products such as spare parts and components are lower technology and could more easily be manufactured by developing countries (E)	Technical issues linked to trade in environmental goods: specificity of HS-codes; sensitivity with regard to dual-use goods; flexibility of lists with obsolete technologies (P)

Source: **Author's elaboration**

Note: **(E), (S), (EV), and (P) are used to identify opportunities and challenges of an economic, social, environmental, and political nature respectively.**

Drawing on the same mechanisms viewed in Section 4.2, liberalization is expected to lower the price of listed goods which would further lead to economic gains and environmental improvements through increased trade, technology diffusion, and learning opportunities (WTO and UNEP, 2009). For instance, the reforms implemented by APEC led to cuts on more than 375 tariff lines averaging 11.6% and affecting a total of USD 31 billion in traded goods, stimulating the diffusion of environmental goods via lower prices and increased returns to scale (Matsumura, 2016; Vossenaar, 2016).

In this respect, it is argued that the rise in environmental goods prices caused by tariffs and other trade barriers would not only slow down the adoption rate of abatement technologies, with the consequent environmental impact including that arising from the prolonged use of fossil fuels, but it would further limit investments in innovation, undercut employment, and put additional stress on natural resources, decreasing the overall social, economic, and environmental welfare of nations (Less and McMillan, 2005; UNEP, 2013; De Alwis, 2015). For instance, it is estimated that the 25% tariff on steel imposed by the US in March 2018 would raise the overall costs of solar- and wind-generated power by up to 5%, negatively impacting on the overall market share of renewable energies (GTM Research, 2018). According to the World Bank (2007) and Yoo and Kim (2011), eliminating tariffs on trade of clean energy technologies would increase international trade in such technologies by at least 6-9%; this outcome would be greater for developing countries whose initial tariffs and price elasticities tend to be higher, and whose small share in brown technologies reduces switching costs and arguably facilitates leapfrogging onto green substitutes (Acemoglu et al., 2012; Altenburg and Pegels, 2012). Furthermore, the increasing participation of emerging economies in the global trade of environmental goods pinpointed in Chapter 3 suggests that gains from trade accrue to a larger number of countries, especially as participation in global value chains allows for an increasing exchange of knowledge incorporated in traded goods and intangibles (Fu, 2018).

Overall, previous UN Environment (2013) work summarized the main economic gains from tariff reduction in environmental goods: (i) lowering prices and increasing consumption; (ii) stimulating environmental goods manufacturing by increasing competition while further reducing costs and outperforming brown technologies; and (iii) expanding nascent green markets and industries by increasing access to environmental goods.

In addition, social gains are realized as new employment opportunities are created and skills transferred. This is the consequence of at least three factors, including the labour-intensiveness characterizing several environmental goods especially in the renewable energy sector (Pollin et al., 2008; Wei, Patadia and Kammena, 2010), the scope for the creation of downstream linkages with the local economy (Ernst & Young, 2017; Monkelbaan, 2017), and the potential that technology transfer has to enhance workers' knowledge and capabilities.

Concerning the first aspect, Fankhauser et al. (2008) show that low-carbon technologies have an immediate positive impact on employment for early movers, while maintaining a long-term potential to create many more jobs than they displace, leading to productivity improvements and growth. For instance, as reported by UN Environment (2015a), the development of Ghana's solar industry entails the capacity to create more jobs than the fossil fuel sector, with an estimated employment of 3,000 direct and indirect jobs for 100 megawatt solar PV installation and the consequent welfare benefits brought about by lower emissions, reduced external costs, and higher export potential. While stressing the challenges in terms of skills requirement and the negative impact of phasing out brown technologies, Esposito et al. (2017) point to several instances in which the development of environmental goods industries has achieved employment creation, including the Noor-Ouarzazate solar power complex in Morocco which created over 1800 jobs, the biofuel sector in Northeast Brazil whose short-term estimated labour creation ranges between 12,500 and 160,000 jobs, and the potential for 4,000 jobs that the expansion of the solar, wind, and hydraulic power market has for the Lebanese economy by 2020.

Regarding the second aspect, the increasing fragmentation of production in global value chains generates employment potential beyond the country of production via the downstream provision of components and services in importing countries (Ernst & Young, 2017, p. 9). For instance, following the recent debate over the introduction of anti-dumping measures to limit imports of Chinese solar equipment in the EU, the Alliance of the Sustainable Energy Trade Initiative warned against a potential loss of 30,000 jobs in installation and maintenance services. This figure significantly outperforms the 15,000 jobs that imports have costed the sector according to the manufacturers association ProSun (ICTSD and WEF, 2013, p. 17; Monkelbaan, 2017). A similar argument has been made concerning the costs that the 2018-approved US tariffs on the import of Chinese solar panels, as mentioned in Section 4.1, will have in terms of downstream employment losses.

Finally, employment gains are not only the consequence of labour-intensive industries and downstream value chain linkages, as this would arguably benefit countries already enjoying a competitive advantage in several environmental goods (e.g. BRIC countries – see Chapter 3). Conversely, opportunities would further accrue to developing countries as knowledge and skills are transferred within global and regional value chains (Cattaneo et al., 2013). Participation in global markets has been shown to correlate with increased employment rates and wages (Flanagan, 2005, p. 129; Maertens and Swinnen, 2009), higher demand for skilled-labour force, and labour productivity (Fafchamps, El Haine and Zeufack, 2007; Bigsten and Gebreeyesus, 2009; Foster-McGregor, Isaksson and Kaulich, 2014).

Moreover, when it comes to EST value chains, employment benefits are likely to be reinforced by the positive spill-over that decoupling environmental degradation has for the welfare of marginalized social groups. For instance, it has been observed how environmental degradation and climate change is particularly detrimental to the livelihood of poor women in Africa. In this region, it is estimated that women account for 70 to 80% of the labour force in agriculture, a sector where "climate change is likely to magnify existing patterns of gender disadvantage" through extreme weather conditions and deforestation (UNDP, 2007). Facilitating trade in ESTs, including organic certified products, can expand the markets for green goods and services and diffuse clean and resource-efficient technologies while further reducing the negative impact of degradation on livelihoods. For example, the introduction of simple ESTs such as solar and biomass cookstoves has been proven to empower women living in poor households in rural regions, who would otherwise have to walk miles in search of firewood (Hart and Smith, 2013).

Despite this evidence, as noted in the United Nations Environment Management Group (UNEMG, 2011) report *Working Towards a Balanced and Inclusive Green Economy*, trade should be further supported by public sector's interventions, including regulations to address environmental externalities, favour gender equality, access to food, water, sanitation and energy services, and contain the negative consequences that the transition to a green economy entails in terms employment and revenue losses. For instance, the concept of circular economy presented in Box 2 has been defined as a way to facilitate the upgrading of polluting sectors and assimilate them within a green economy.

4.4.2. Challenges of liberalizing trade in environmental goods

Despite these benefits, several challenges have been associated with an immediate and unconstrained liberalization of trade in environmental goods. These are mostly connected to the present imbalances in the global trade of environmental goods described in Chapter 3 (Figures 3.2 and 3.3), whereby developed countries account for over 50% of the total trade while the share of developing countries is disproportionally driven by China with non-BRIC developing economies' trade-deficit steadily increasing over the last decade.

Firstly, benefits for importing countries remain unclear and dependent on a complex interplay of several factors. Tamini and Sorgho (2016) point to how trade liberalization leads to increased competition and lower profit margins in countries where starting tariffs

Box 2: Circular Economies and trade liberalization

A *circular economy* is a business model in which residuals from a production process are fed back into the supply chain via *waste out systems* such as recycling, repairing, and remanufacturing (EMF, 2017). Annex 7 discusses how trade liberalization increases the risk that resources made available through ESTs are offset by a *scale effect*. Circular economies are observed to limit such monotonic effect by decoupling production from resource consumption (Wijkman and Skånberg, 2016). Whilst it is recognized that circular economies reduce a country's dependency on import of resources (WRAP, 2018),[48] a reduction of tariffs on ESTs is expected to facilitate the implementation of such models by reducing operational costs, facilitating technological exchange, and increasing the scope for international cooperation. For instance, the ISL-TEDA industrial symbiosis project between China and the UK shows how firms can cluster together to make efficient use of wastes from one another as inputs in their production process (Wang, Deutz, and Gibbs, 2015).[49] Here, a multi-country effort increases potential gains for private firms, including larger government procurement contracts, knowledge sharing, and cheaper access to resources that would otherwise be too costly or unavailable. Moreover, a liberalized economy granting the free circulation of capital and human resources further scales environmental and social benefits of circular models. For example, it is estimated that by investing in a circular economy, the EU single market could create a net benefit of EUR 1.8 trillion by 2030 (EUR 0.9 trillion more than in the current linear development path) while further halving CO2 emissions (EMF, SUN, and McKinsey & Co., 2015). In addition, opportunities for employment are created as the remanufacturing and recycling sectors are expanded and the development of local reverse logistics promoted (EMF, 2015).

are high and trade costs elasticities more pronounced, making it difficult for exporters of environmental goods to maintain their market share upon liberalization.[50] According to the analysis in Chapter 3, benefits would therefore be limited to developed countries and the BRIC states. Similarly, according to Howse and Van Bork (2006), liberalizing trade in environmental goods would generate an increase in exports of developed and transition economies that would be considerably larger compared to African and Latin American countries. Again, He et al. (2015) show how a decrease of environmental goods tariffs in the APEC region, whilst increasing exports for net exporters, have no significant impact on importing countries, suggesting the presence of other non-tariff barriers to trade.

Furthermore, Mathew and De Cordoba (2009) evaluate the impact of liberalizing trade in environmental goods in 14 countries accounting for 75% of the total trade in environmental goods under two scenarios: full-liberalization and a Swiss-formula with differential coefficient for developing countries. Considering the trade, revenue, and welfare effect of these scenarios, the authors show how gains from trade would accrue exclusively to developed countries as their imports would grow relatively less than their exports and further argue for the adoption of a Swiss-formula to ensure that firms in developing countries have the required time to gain competitive advantages. Similarly, according to Dijkstra and Mathew (2016), the adoption of more energy-

Footnotes

48. In the UK, it is suggested that an efficient circular-based economy could improve the country's trade balance by 1 to 2% of GDP by considerably reducing the import of inputs in the supply chain (WRAP, 2018).

49. Balke et al. (2017, pp. 123–125) present three cases of successful industrial symbiosis. These are the Iskenderun Bay Industrial Symbiosis Programme in Turkey, the Yixing Economic and Technological Development Zone in China, and the collaboration between the UK's National Industrial Symbiosis Programme and the Tianjin Economic-Technological Development Area (ISL-TEDA industrial symbiosis project).

50. This is based on research showing how lowering trade costs (e.g. via reducing tariffs) can lead to increased competition and lower profits, making it harder for small exporters to defend their market share upon liberalisation (Melitz and Ottaviano, 2008).

efficient technologies generated by a reduction of environmental goods tariffs leads to an increase in demand which partly offsets potential energy savings. Accordingly, the authors suggest a South-South agreement in which developing countries liberalize trade in ESTs with economies whose environmental technologies are at a similar stage of development. This would further stimulate R&D, increase welfare, and improve the sector capacity to face competition from more advanced eco-firms. South-South cooperation as a vehicle to increase trade in environmental goods while further fostering innovation has been discussed by other authors (Walz, Pfaff, Marscheider-Weidemann, and Glöser-Chahoud, 2017). UN Environment (2014) suggests a combination of open trade policies and regulations to increase the demand for environmental goods with a focus on increasing competitiveness in mature technologies such as solar PV components, module assembly, and balance of system components. Looking at the case of a large South African energy firm investing in Uganda, Manyuchi (2017) further argues that transnational corporations from the South are particularly efficient in transferring and implementing cleaner technologies in other developing countries.[51] Simlarly, Walz et al. (2017) show how South-South trade in ESTs is growing faster than all other segments, with an increasing tendency towards regionalization, especially in East Asian and Central American markets.

Secondly, concerning the environmental impact of environmental goods trade liberalization, using a system of simultaneous equations that explain pollution, environmental regulation stringency, and per-capita income for transition economies, Zugravu-Soilita (2018) shows how the harmful impact of environmental goods' trade intensity on air pollution is offset by its indirect impact on environmental regulations through income generation.[52] The author concludes that if trade tariffs have a positive impact on the income of developing countries, trade liberalization without export promotion policies would be unwarranted. In a similar way, according to Nimubona (2012), in a market dominated by few large producers, reducing tariffs on environmental goods is likely to increase imports encouraging a process of rent-transferring from governments to foreign firms. In this context, environmental benefits are realized at the expense of social welfare, while governments may compensate for the lost rents by further reducing abatement costs.

For this reason, it has been argued that it is first of all pivotal to foster a regional market to increase competition and ensure social welfare along with environmental protection (Vossenaar, 2010; Zhang, 2009). For example, several African countries, despite having low tariffs on many environmental goods, do not import them due to a lack of absorptive capabilities and purchasing power. In such a context, reduction of tariffs would have little or no effect unless it is implemented alongside measures aimed at market creation, which includes financial assistance, differential treatment provisions, relaxation of intellectual property rights regulations and fees to favour technology adoption, and, more generally, the removal of non-tariff barriers that constrain access to global markets (Zhang, 2013).[53]

Finally, to the extent that the participation of developing countries and LDCs in ESTs' value chains is more likely to involve the provision of upstream components (Hammeren, 2014; UNEP, 2014, 2015a), a critical challenge is represented by environmental goods

Footnotes

51. Moreover, the study confirms previous literature on how stringent environmental regulations encourage cross-border trade in environmental goods (Dekker, Vollebergh, De Vries, and Withagen, 2012; Popp, Hafner, and Johnstone, 2011; Sauvage, 2014).

52. The author refers exclusively to end-of-pipe environmental goods. Moreover, contrary to air pollution, the scale effect is observed to offset any potential benefit on reducing water pollution (Zugravu-Soilita, 2018).

53. As reported by Zhang (2013), "[m]ost of the increase in developing country exports of PV devices and wind turbines between 2004 and 2008 was largely driven by regulations that mandate specific shares of renewable energy in the total energy supply, favourable feed-in tariffs and other incentives in developed countries."

whose inputs are not environmental goods themselves (Steenblik, 2005b). For instance, the production of wind turbines is energy intensive and relies extensively on the use of fossil fuels and metals (e.g. neodymium) whose production process constitutes an environmental hazard. Similarly, the polysilicon adopted in the production of solar cells generates tetrachloride, a highly polluting byproduct (Jha, 2013; Sugathan and Brewer, 2012; Wan et al., 2018). Tariffs on these goods would not only have a negative impact on the price and output of final ESTs, but they could further damage the economy of developing countries producing them. In this respect, it has been argued that replacing dirty components with cleaner and costlier ones, whilst posing an initial challenge to developing countries competing in global value chains, is likely to foster innovation and competitiveness in the long run (Ambec, 2017). Moreover, recent research modelling the effect of trade liberalization in environmental goods employing dirty components points to the need for environmental policy to support trade liberalization and ensure that its benefits improve welfare in both intermediate- and final-goods producing countries (Wan et al., 2018).

When it comes to the negotiation process and the implementation of liberalizing policies for environmental goods, there are a number of technical issues whose relevance has been already sufficiently emphasized in the literature (Cosbey et al., 2010; Hammeren, 2014; Steenblik, 2005b; Sugathan, 2013a; UNEP, 2015c). These include: (i) the breadth of HS subheadings which prevent an exact identification of many environmental goods; (ii) the dual-usage of goods that can have an environmental application but non-environmental ones as well; and (iii) the flexibility of a potential list to accommodate future technological change, to the extent that technical innovations benefitting the environment today will likely become less and less representative in the future.

4.5. Environmental services: Opportunities and challenges

With a restricted focus on waste treatment and de-pollution, agricultural and mining services in 33 countries (all developed countries with the exception of Russia and Colombia), Chapter 3 pointed to a growth of over 700% of trade in environmental services between 2006 and 2014 – larger than the growth of trade in environmental goods for the same period. Whilst the definition of environmental services remains disputed (Sauvage and Timiliotis, 2017), it is clear that knowledge-intensive services associated with the installation, maintenance, and overall functioning of environmental goods require an extensive exchange of technology and skills that can benefit developing countries both in terms of competitiveness and capacity building. The following subsections present a number of opportunities and challenges that are unique to trade in environmental services and extend across most of the definitions and lists provided in Section 1.2. These are further summarized in Table 4.4.

4.5.1. Gains from liberalizing trade in environmental services

There are a number of opportunities that can be associated with the liberalization of trade in environmental services. These include a larger market size and a tendency towards localization, the complementarity between several environmental services and environmental goods that increases the potential for employment and knowledge transfer while further facilitating the scope for plurilateral negotiations, the comparative advantage that developing countries feature in certain ESTs such as water purification, organic agriculture and their associated environmental services, and the more flexible WTO regulations associated with environmental services compared to environmental goods. These opportunities are addressed in the following paragraphs.

Due to its higher potential for localization, the service sector is often considered as the low-hanging fruit for developing countries willing to enter global value chains and foster market linkages with their local industry (Meier, 1995; Fessehaie, 2012; Parrilli, Nadvi and Yeung, 2013). For instance, the analysis in Section 3.8 features both Russia and Colombia, the only two developing countries in the 33 countries sample, among the top-six traders in waste treatment and de-pollution services, suggesting a potential

Table 4.4: Opportunities and challenges linked to the liberalization of trade in environmental services

Opportunities	Challenges
Environmental services present a larger and more localized market than environmental goods, with significant opportunities for developing countries to enter the value chain (E)	Difficulty in measuring trade due to constraints in collecting data on environmental services –including those arising from localisation and alternative modes of supply (P)
Complementarity of environmental services and environmental goods increases potential for innovation and knowledge transfer via mode 3 and 4 (see Table 4.5) (E)	Non-tariff barriers linked to the free circulation of people and capital (see Table 4.6) (P)
Complementarity of environmental services and environmental goods implies the potential for job creation in downstream services (S)	Conflicting interests of environmental goods' and environmental services' providers complicating the definition of harmonized national and transnational green industrial policy interventions (E)
Larger room for manoeuvre in defining green industrial interventions compared to environmental goods (more flexible WTO regulations) (P)	Social and economic externalities due to uncoordinated liberalisation: limited access to basic services and service providers concentrated in developed countries (S, E)

Source: **Author's elaboration**

Note: **(E), (S), (EV), and (P) are used to identify opportunities and challenges of an economic, social, environmental, and political nature respectively.**

comparative advantage for emerging economies in the provision of certain environmental services. Moreover, Yu (2007) reports that environmental services in Asia represent a much larger sector than the one for environmental goods, and Ikiara and Mutua (2004) further describe Kenya's share in ESTs as mostly occupied by eco-tourism and waste-management services. Monkelbaan (2013) estimates that 70% of the value added in the installation of solar panel remains in the country of installation mostly in the form of services, even when panels are imported as it is the case for most developing countries. Similarly, the work of Sauvage and Timiliotis (2017) on trade in environmental services and the analysis presented in Section 3.8 of this report (Table 3.11) further show how, with the exception of North American firms, large environmental services providers tend to operate mostly regionally.

An important feature of environmental services is that they are often complementary to and indispensable for the efficient implementation of environmental goods. Drawing on interviews with large environmental services providers, a study by the Swedish Government on the interdependency between environmental goods and environmental services concluded that "without services, [there is] no environmental goods trade" (Kommers, 2014a). The study shows how several environmental services (presented in Table 4.5) usually accompany the sale and use of environmental goods spanning the pre-, peri-, and post-delivery phase. Li et al (2013) further reports how 70% of environmental services in the APEC region are connected to the use of environmental goods, particularly in the domains of solid and hazardous waste management, air pollution control, and wastewater disposal. To the extent that most of these environmental services originate from the country producing the technology, providers' competitive advantages rest

Table 4.5: Lists of required services accompanying environmental services

Service	Purpose	Mode of supply	CPC prov
Assembly and installation	Guarantee the basic functioning of the product	1, 2, 3, 4	885, 867, 516
Technical testing and analysis services	Guarantee the basic functioning of the product, e.g. fulfil regulatory demands	1, 2, 3, 4	8676 (94 and 84)
Educational services	Guarantee a proper use of the product, Improve product and user efficiency	2, 3, 4	924, 929, 8673
Advisory and consultative services	Increase customer satisfaction, fulfil regulatory demands	1, 3, 4	86711, 86721
Maintenance and repair services	Guarantee the basic functioning of the product	1, 3, 4	88, 8862
Computer services	Guarantee the basic functioning of the product	1, 4	84

Source: Adapted from Kommers (2014a) and Li et al. (2013). The list extends the definition of environmental services to cover both infrastructure and non-infrastructure service provision, as suggested by Geloso Grosso (2007).

on their capacity to offer a customized package of services that adapts to different environmental regulations, standards, and climate conditions. This implies that, in order to ensure the effective implementation of environmental goods, companies need to supply a set of services which is done in four possible ways: via cross-border trade (mode 1), by consumption of the service in the country of origin (mode 2), through a commercial presence of the service provider in the host-country (mode 3), and/or via physical movement of the service provider to the host-country (mode 4).[54] Examples of these services, their relative CPC prov, and mode of supply, are presented in Table 4.5.[55]

The complementarity of environmental services and environmental goods represents a major opportunity to the extent that it increases the potential for innovation and knowledge transfer, especially when environmental services are supplied under modes 3 and 4. As presented in Section 1.3, technology and innovation can be exchanged independently of conventional trade channels through licensing, the provision of consultancy services, foreign direct investment, or simple business collaborations (Fu, 2018). According to a survey of 61 ES-CE providers accounting for about 40% of the market for global ES-CEs, firms generate on average half of their turnover abroad with a staggering trend in recent years (Sauvage and Timiliotis, 2017). This unveils an increasing use of mode 3 type of environmental services' supply that tends to be more relevant among larger firms, further disclosing a phenomenon of market concentration that does

Footnotes

54. The four modes of services supply have been defined by the GATS.
55. Due to the scarcity of disaggregated data for environmental services, to our knowledge, only one study has systematically evaluated the impact of restrictions in trade of environmental services on countries' supply of such services via mode 3 (Sauvage and Timilioti, 2017).

not emerge from conventional export statistics.[56] With most environmental services requiring a commercial presence abroad (i.e. mode 3), emerging economies would experience welfare gains through job creation, higher salaries, and knowledge transfer via local partnership and employment opportunities.[57]

In such a context, developing countries should aim at developing environmental services associated with ESTs in which they stand a competitive advantage. A UN Environment (2014) study on South-South trends in ESTs' trade point to the growing opportunities that developing countries stand in water purification, renewable energy, and organic agriculture. Moreover, the RCA analysis presented in Chapter 3 further points to wind towers and lattice masts (HS 730820) and solar PV wafers, cells and modules/LEDs (HS 854140) as product categories where a greater number of developing countries present a comparative advantage. A strategy aimed at nurturing environmental services complementary to these goods represent a fundamental component for a transition towards a green economy. According to UN Environment (2014), South-South trade in water filtration and hydropower equipment for instance accounted for 23.1 and 45% respectively. Similarly, Chapter 3 pointed to photosensitive semiconductor devices (HS 854140) as goods with a comparatively larger share among developing countries, with a fast-growing trend in China, the Republic of Korea, and Malaysia. A focus on fostering skills associated with services linked to these goods could enable developing countries to deliver such services (including related know-how) through mode 3 and mode 4, particularly to other developing countries facing similar market conditions.

Furthermore, within the plurilateral WTO EGA negotiations, complementarity implies that parties could more easily agree on liberalizing services directly related to the installation, maintenance, R&D and consulting related to an accepted list of environmental goods. Links between environmental goods and environmental services can further ease the identification of environmental services with a dual usage, as exemplified in the OECD/Eurostat and APEC lists presented in Table 3.7 in Section 3.8.

Finally, another opportunity associated with environmental services rests on the larger room for manoeuvre that developing countries have in defining green industrial policy. In fact, the use of green industrial policy by national governments to support the environmental services sector is less controversial than in the case of environmental goods. This is because WTO rules disciplining national industrial policy in the service sector are much less strict than those for goods, allowing the use of green subsidies and other vertical policies aimed at favouring local firms over foreign competitors (Cosbey, 2017). For instance, while the use of tariffs and other non-tariff measures involving trade in goods is strictly disciplined under the GATT, to which most countries have already committed, the correspondent GATS is much more flexible in how countries commit to liberalize their respective markets, allowing members considerable leeway in choosing sectors for market access commitments. In addition, the GATS also allows leeway with regard to prescribing conditionalities associated with investment by a service provider. So, for example developing countries could open up specific environmental services sectors but also lay down the condition that service providers must source a certain percentage of their workforce locally and impart them the required training and skills in the operation and maintenance of the technology used to deliver the service.

Footnotes

56. In fact, the market for environmental services such as hazardous waste management and wastewater treatment is extremely concentrated with the top 20 firms having 70% and 67% of market share respectively. Similarly, the top-10 firms providing air-quality services occupy a 69% of the global market share (ENR, 2016).

57. Refer to Section 4.4 for a discussion on how import of environmental goods has the potential to foster the downstream service and component sectors of importing economies.

4.5.2. Challenges of liberalizing trade in environmental services

The literature presents a set of challenges that are specifically linked to environmental services. These include the difficulty in tracking trade due to their localization and mode of supply, the fact that they are mostly affected by "behind the border" non-tariff barriers linked to the free circulation of people and capitals rather than standard tariff barriers, the presence of a trade-off between environmental goods and environmental service providers when it comes to green industrial policy and infant industry arguments, and the risk that uncoordinated liberalization would have negative social and economic externalities in developing countries. Each of these challenges is addressed in the following paragraphs.

Contrarily to goods, environmental services have not been included in the APEC agreement and are not as yet part of the WTO plurilateral EGA negotiations (Baltzer and Jensen, 2015; Araya, 2016). Despite the synergy existing between environmental goods and services, the latter's absence from the negotiations tables is allegedly due to the complexity in identifying and quantifying barriers to trade in environmental services (Bucher, H. et al., 2014). Chapter 3 further pointed to the lack of reliable data on environmental services, especially for developing countries. This is in turn linked to the different modes in which services are traded: not only are they not directly identifiable by direct association with the harmonized HS-coding system, but their localization makes them more dependent on cultural and linguistic similarities than on countries' tariff structures (Hufbauer, Brunel and Rosa, 2009). In this respect, localization can often represent a technical challenge when it comes to data collection and negotiations focused on trade barriers.

Despite those facts, it is important to notice that the localization of environmental services does not mean that international trade is not taking place, but rather that this mostly occurs under the modes of supply presented above; particularly mode 3 and 4 (Kommers, 2014a). In other words, while the service is issued locally, the personnel, skills, and further coordination may originate from abroad. As environmental services increasingly rely on the free movement of personnel and the possibility for environmental goods providers to establish commercial presence abroad, non-tariff barriers limiting the circulation of people and capitals are likely to negatively impact on the trade of environmental services. According to Sauvage and Timiliotis (2017), countries' trade restrictions on the circulation of environmental services are associated with a lower export performance of their environmental services' exporters, reflecting the anti-competitive nature of restrictions hindering the entry of new competitors.[58] The most relevant restrictions affecting trade in services via mode 3 and 4 are presented in Table 4.6 and include a series of legal and bureaucratic obstacles that prevent, delay, and/or increase the cost associated with environmental services' provision.[59]

The potential for localization associated with environmental services further complicates the situation when it comes to trade disputes and the use of green industrial policy. In fact, to the extent that installation and maintenance services rely on the availability of cheap environmental goods, restrictions on imports aimed at favouring local manufacturers can negatively affect the local environmental services sector, including

Footnotes

58. This aspect further resonates with the literature on learning-by-exporting already reviewed in the previous sections. Drawing on a survey of 61 providers of environmental services, Sauvage and Timiliotis (2017) conclude that exporting firms are significantly larger, more productive, and pay higher wages compared to their domestic-oriented counterparts.

59. Barriers to trade in services have been defined in the World Bank's Services Trade Restrictions Database (Borchert et al. 2014) as well as in the OECD's Services Trade Restrictiveness Index, which carries out an extensive review of over 10,000 national regulations and identify those policies that prevent trade across services such as engineering and telecommunications. Whilst not specific for environmental services, the index covers several trade barriers including restrictions on foreign entry, on the movement of people, as well as barriers to competition and regulatory transparency.

Table 4.6 Challenges faced by environmental service providers using mode 3 and 4

Mode 3
Requirements for joint-ventures
Requirements for the employment of local work-force
Security regulations on data transfer
Restrictions on the legal form of companies
Investment screening procedures (equity limits, economic-needs test for commercial presence…)
Government procurement favouring local suppliers
Limited eligibility for subsidies, including tax benefits
Government procurement favouring local suppliers
Restrictions on the acquisition of land and real estate
Mode 4
Lengthy visa applications preventing effective short-missions by environmental services providers
Complex bureaucratic requirements such as "letters of invitation" to enter country for work-related purposes
Professional qualification exams / limited recognition of third-country diplomas and qualifications
Limitations on the duration of stay of foreign providers
Public monopolies restricting entry of private services providers (also mode 3)
Nationality or residency requirements for accreditation of certain types of services

Source: **Author's elaboration based on Sauvage and Timiliotis (2017) and Kommers (2014a).**

downstream jobs generation. For instance, the early-2018 restriction imposed by the US administration on the import of solar panels and cells is expected to cost several thousands of jobs to the solar industry, where over 85% of the total 260,000 labour force is employed in services related to panel installation and maintenance (Sampathkumar, 2018). The example provided in Section 4.4 concerning the negative impact of EU anti-dumping measures on employment in the solar service sector is also explanatory in this respect (ICTSD and WEF, 2013, p. 17).

Finally, whilst agreeing on the positive effect that liberalizing trade in environmental services would have for developing countries in terms of economic, social, and environmental benefits, Geloso Grosso (2007) warns against the social consequences of reforms that are not backed by solid regulatory mechanisms and institutions. For instance, environmental services such as water- and solid-waste management, if left to the private sector, will likely exclude a large segment of the poor population as firms prefer to invest in major urban areas at lower risk. For this purpose, state intervention should include obligations for private firms to extend service networks, quality and environmental standards, while further subsidizing consumers' access to the latter. This process requires an efficient administrative body and an independent competition authority to protect consumers' interests against potential abuses.

Economic externalities can emerge to the extent that intellectual property rights may also prevent knowledge transfer, especially in services that are strictly connected to the installation and use of specific environmental goods and technologies (Correa, 2013; Morsink et al., 2011; Oh, 2017). For instance, despite having grown to be the number one exporter in environmental goods, China still imports several basic environmental services in sewage treatment and garbage disposal, suggesting the need for an institutional action plan to promote and facilitate the dissemination and usage environmental services-related skills (Li et al., 2013). In the same way, while arguing for trade liberalization, Sauvage and Timiliotis (2017) notice how most exporters of environmental services remain concentrated in North America and Western Europe, with high entry barriers due to the large economies of scale characterizing the sector.[60]

Considering the complementarity between environmental goods and services, the potential benefit of liberalizing trade in the former is likely to be much greater if barriers to trade in environmental services were to be included in the negotiations. Ignoring their relevance would make the diffusion of ESTs unnecessarily expensive as firms trading in environmental goods struggle to procure the required service inputs at competitive prices.

4.6. EPPs: Opportunities and challenges

EPPs have been defined in Section 1.2 as products that, at one or more stages of their value chain, cause significantly less environmental harm than alternative products serving the same purpose (UNESCWA, 2007). Whilst reducing EPPs to a very limited list of single-use HS subheading, Chapter 3 estimates the total trade in EPPs to about USD 200 billion in 2016, a third of which is traded by developing countries. The following subsections present the main opportunities and challenges associated with liberalizing trade in EPPs. Table 4.7 further summarizes the main themes discussed in the section.

Footnotes

60. While both OECD and APEC point to the need for policy cooperation to address barriers that handicap environmental services-related technology dissemination, no transnational effort exists yet. Bilateral efforts such as the US–China Clean Energy Research Center (CERC) have produced considerable global benefits in this respect and could be used as a model for collaborative R&D for other countries (Lewis, 2014a).

Table 4.7 Opportunities and challenges linked to the liberalization of trade in EPPs

Opportunities	Challenges
Enhancing developing countries' potential gains from trade as they stand comparative advantages in several EPPs (E, S)	Technical difficulty in identifying and classifying EPPs: specificity of HS-codes, flexibility of any potential EPPs list (P)
Favouring participation/inclusion of developing countries in the negotiations (P)	Lack of harmonized regulations and standards providing a system of governance (P)
Economic, social, and environmental benefits associated with certified agriculture and aquaculture (see Annex 8) (E, S, EV)	Overcoming non-tariff barriers linked to development and commercialization of certified agriculture and aquaculture (see Annex 8) (E, P)
Reducing future switching costs for many countries whose industrial growth is expected to occur between now and 2030 (E, EV)	Mercantilist approach adopted by negotiating countries (P)

Source: **Author's elaboration**

Note: **(E), (S), (EV), and (P) are used to identify opportunities and challenges of an economic, social, environmental, and political nature respectively.**

4.6.1. Gains from liberalizing trade in EPPs

Opportunities from liberalizing trade in EPPs accrue mostly to developing countries, which have a relatively strong presence in EPP trade as compared to other sectors. These include the potential for enhanced gains from trade and the positive externalities that these countries' participation in a future deal on ESTs would entail for the international community.

As observed in Section 1.2, EPPs include many commodity- and agricultural-based products in which developing countries and LDCs maintain a competitive advantage connected to their abundance of cheap labour, land, and natural-resources. In this sense, despite being net importers of traditional environmental goods, several developing countries present a strong potential for becoming net exporters of EPPs (UNCTAD, 2005; Zugravu-Soilita, 2018). For instance, the largest producer of jutes and sisal in the world are Bangladesh and Brazil respectively, and China is the largest producer of bamboo – all products with short harvest cycles and minimum input requirements (EC, 2016b, p. 137). An investigation into the trade pattern of countries participating in the Doha Round shows that Asian LDCs have a comparative advantage in EPPs, which make up a lion's share of their environmental goods exports (72.17% in 2007) (Khatun, 2012; Yoo and Kim, 2011).

As presented in Table 1.1, trade liberalization in EPPs has been advocated by UNCTAD (2005) and it is included in the scope of the 2001 Doha Ministerial Declaration. In this respect, the inclusion of EPPs in the negotiations would not only trigger a more active participation of developing countries in the trade talks, but it would also ensure that approved regulations are not discriminatory against LDCs (Araya, 2016; Khatun, 2012; Wu, 2014).

Failure to address the inclusion of EPPs in any negotiation to liberalize trade in ESTs would increase future switching costs for a large number of countries whose industrial growth is expected to occur between now and 2030 (Cosbey, 2008). To the extent that most LDCs' energy and urban infrastructures are yet to be built, securing their participation in a future deal that includes both EPPs and environmental goods would further benefit developed countries with an advantage in the production of advanced ESTs, favouring a more efficient allocation of resources and avoiding the risk that a delayed *greening* process would entail. Particularly, to the extent that EPPs based on PPM are included, higher consumption of EPPs in developed countries will also result in positive environmental and social impacts in developing countries, particularly LDCs (EC, 2016b, pp. 139–140; Howse and Van Bork, 2006).

Annex 8 provides an overview of the benefits and avoided-costs attached to EPPs associated with certified organic agriculture and aquaculture. The analysis is extracted from four UN Environment studies on the eco-labelling of food and wine in Chile, the production and processing of certified shrimps and pangasius in Viet Nam, the bio-trade of quinoa and maca in Peru, and the organization of certified organic farming in South Africa. With the exception of pangasius production in Viet Nam, all studies point to the triple-win situation generated by organic and bio-trade certifications that favours trade expansion, social welfare, and environmental protection. Producers and processors entering certified value chains experience higher profits through premium prices and increased corporate reputation, reduced poverty, and improved access to water and nutritional levels. In addition, due to its higher skill- and labour-intensiveness, organic certified farms employ more and better skilled-workers over a longer growing season than conventional agri-business (Morshedi, Lashgarara, Hosseini, and Najafabadi, 2017; UNEP, 2016c). For example, farms engaging in certified shrimps' aquaculture in Viet Nam registered a 4% increase in jobs and 5% improvement in workers' average annual salary triggered by the higher skill-level and productivity of the workforce. In addition, economic gains featured a 12% increase in sales volumes and a 15% increase in profits compared to the year before certification (UNEP, 2016b).

From an environmental perspective, organic agriculture and aquaculture maintain higher degrees of biodiversity than conventional production systems, while producing lower area-related emission and preventing soil erosion and water pollution (Bengtsson et al., 2005; Lazzerini et al., 2014; Schader, Pfiffner, Schlatter, and Stolze, 2008). Moreover, by reducing the costs associated with fertilizers and pesticides, groundwater purification, and food scarcity due to productivity losses, organic and bio-trade certified production further improve farmers' health and welfare (Baran'ski et al., 2014; UNEP, 2016c), while indirectly increasing education as households can afford schooling fees. Soil preservation also reduces the cost of urbanization associated with the abandonment of agricultural land, while protecting biocultural diversity embedded in ecosystems and human cultures (Maffi and Woodley, 2010). In addition, since organic production reduces the need for purchasing agro-inputs, a practice that in several developing countries is dominated by men, this is further expected to empower women operating in the farm (UNEP, 2016c, p. 46). For instance, a feasibility study on the bamboo sector and supply chains in Viet Nam, the Lao People's Democratic Republic and Cambodia by the International Finance Corporation, Oxfam and the Mekong Private Sector Development Facility estimates that 60% of the workforce in Viet Nam in certain products such as bamboo handicrafts and nearly half in bamboo flooring are women (Marsh and Smith, 2007).

Improved soil, air, and water quality, along with reduced greenhouse gas emissions and better forest preservation are among the main environmental gains characterizing the EPPs analysed in the UN Environment case studies. For instance, it is estimated that certified bio-trade quinoa in Peru generated 10-17% higher profits, reducing soil deterioration and lowering the costs of wastewater treatment from USD 96.1 to 47.5 per hectare (UNEP, 2015b). In Viet Nam, certified shrimps and pangasius achieved up to 8% higher survival rates. Similarly, in Chile, where agriculture uses 73% of the country's water resources and is one of the major causes of soil erosion, salinization, pollution, and fertility loss, a shift to organic agriculture is observed to reduce soil contamination and further decrease water wastage by retaining up to 100% more water than conventional methods (Rayden and Essame Essono, 2010; UNEP, 2016a).

4.6.2. Challenges of liberalizing trade in EPPs

Despite the benefits and opportunities associated with trade in EPPs, at the point of writing, neither the APEC negotiations nor the ongoing plurilateral WTO EGA have taken a clear stance on the inclusion of EPPs in the talks, with the APEC 54 list including only one EPP. The main rationale for excluding this category relates to the practicality of identifying and tracking trade in EPPs. Accordingly, to the extent that the international HS identifies goods by their end-use, it becomes particularly challenging to distinguish products based on their production and/or disposal methods (Cosbey et al., 2010; EC, 2016b, p. 136; Steenblik, 2005b; UNEP, 2015c). For instance, the EU note to the environmental goods list provided as part of the WTO EGA negotiations states that "[t]he selection of products to be included in the EGA is made on the basis of their end-use rather than production methods. This is because there is no common international methodology that would allow assessing the environmental performance of a product throughout its life cycle" (EC, 2016a).

Another technical aspect of controversy relates to EPPs which, despite having an environmental end-use, undergo a polluting production process. The European Commission (2016b) report on environmental goods stresses how, during the consultation preceding the report, bicycle manufacturers from across Europe provided strong evidence that their production methods were overall less polluting than bicycles produced outside the EU such as China.

To the extent that several ESTs are already exported duty-free in most countries participating in the WTO EGA negotiations, scholars have argued that liberalizing trade in ESTs without addressing EPPs would give greater benefits to net exporters of the listed goods (Cosbey, 2014; Hammeren, 2014). Such benefits are further amplified by the mercantilist approach adopted in the negotiations (Harashima, 2008), with countries agreeing to liberalize trade of environmental goods already featuring low tariffs (where tariffs are used as a proxy of the sector lobbying capacity) and in which they possess a comparative advantage. This further implies that stakes would be higher for non-participants, a group overwhelmingly constituted by LDCs and developing countries (Balineau and De Melo, 2013).[61]

As the interest of LDCs for ESTs lies essentially with EPPs (Jha, 2008; UNESCWA, 2007; Yoo and Kim, 2011), scholars studied potential mechanisms to include these goods in the WTO negotiations (Vossenaar, 2013; 2016; Wu, 2014). According to Araya (2016) and Yu (2007), negotiations can attract developing countries only if they cover products and services in which these countries have a competitive advantages, while Cosbey (2014) goes a step further to suggest the creation of an external regulatory body in charge of listing and delisting goods, as well as revising performance standards for inclusion. Despite these efforts, no official mechanism to overcome the technical difficulties related to the inclusion of EPPs in a potential deal has been formally discussed or adopted. As a note, the APEC list does include one EPP (i.e. bamboo flooring panels), which represents nevertheless the only exception in the list; further warranted by the fact that its environmental scope is unique and directly identifiable via the 6-digit HS-code – 441882 (Vossenaar, 2013).[62]

Footnotes

61. A similar approach is further observed in environmental services, where major providers are also those with the highest trade and non-trade restrictions in place (Sauvage and Timiliotis, 2017).
62. The WTO Friends' List also included a series of EPPs products derived from natural-fibers since they generate much less carbon at harvest and can biodegrade relatively quickly then plastic-based

Another major challenge associated with EPPs, in particular those related to agri-business, is the lack of harmonization among the plurality of standards and sustainability criteria at the national and regional level (IFOAM, 2011; UNEP, 2013). Examples of how private and public information-based instruments such as eco-labelling schemes and standards can impact on consumers' choices and improve both economic and social welfare of producers are multiple (Beuchelt and Zeller, 2011; Morshedi et al., 2017; UNEP, 2011, pp. 140–141, 2013). Yet, schemes at the national level remain mostly market-based and not statutory, preventing a systematic use in customs classifications and tariff treatment (Howse and Van Bork, 2006, pp. 10–11). Overall, despite a growing number of initiatives, the lack of harmonized environmentally responsible production standards further constrains market development and hampers market access to the detriment of smallholders in developing countries (Essaji, 2008; UNEP, 2016c).

According to the UN Environment case studies presented in the previous section, the benefits from increased trade in organic and certified EPPs outperform costs. Nevertheless, non-tariff barriers remain a major challenge to unfold some of the economic, social, and environmental opportunities associated with EPPs. In particular, the summary table of challenges related to EPPs in Annex 8 points to the high entry barrier constituted by certification costs, which negatively affects smallholders; this is even more controversial if considering that many small farmers already use uncertified environmental techniques without accessing their market benefits (UNEMG, 2011). Furthermore, low knowledge and skills in both the private and public sector act as a limitation to expand these sectors' potential and favour upgrading within global value chains. This is in spite of the fact that organic agriculture has been associated with higher opportunities for producers to capture extra value via in-farm processing, marketing, and retailing (Morshedi et al., 2017; UNEP, 2016c, p. 42). Other major challenges that emerge from the case studies are: the potential lower yields of organic farming compared to conventional agriculture, the dependency on foreign markets for fertilizers and technological inputs, the lack of effective financial facilitating mechanisms for smallholder producers, and the already-mentioned lack of standards' harmonization, which increases certification costs and further restricts market access.

4.7. Summary of opportunities and challenges of EST trade liberalization

Using the list of HS subheadings reported in Annex 1, Chapter 3 presented a set of statistics describing trade patterns in environmental goods and selected EPPs and services. Overall, the analysis pointed to an imbalance between developed and developing countries, with the former accounting for over 50% of the overall trade. Whilst pointing to a trade-surplus among BRIC countries (disproportionally dominated by China), the analysis further highlighted a deficit in the balance of payment of non-BRIC developing economies and, particularly, LDCs. With the exception of some EPPs, only China and Mexico feature among the top-10 global traders in ESTs, while LDCs remain mostly insignificant. In this respect, one of the main conclusions emerging from the data is that the technological composition of ESTs trade – both on the import and export side – tends to be related to a nation's level of development (cf. Section 3).

Building on the findings of Chapter 3, Chapter 4 explored the economic, social, and environmental consequences that liberalization of trade in ESTs would have for the economies of developing countries and LDCs. In other words, considering the global imbalances that affect trading patterns, this chapter tried to answer the following question: how could developing countries benefit from liberalization processes as initiated by the ongoing WTO EGA and the recent APEC agreement described in Chapter 2?

Overall, the findings confirm the role of trade liberalization as a mechanism to decouple growth from environmental pollution by favouring the diffusion and adoption of green technologies, while further facilitating the phasing-out of more polluting alternatives.

In particular, it has been observed how the reduction of import and export tariffs lowers the cost of accessing ESTs, further decreasing abatement costs and favouring industrialization as local companies enter global value chains and benefit from learning-by-exporting. Furthermore, proponents of the Environmental Kuznets Curve hypothesis pointed to the positive role that income growth has on reducing pollution in the long term. Nevertheless, critics have warned against the risk of immiserizing growth generated by staggering competition among local firms entering global value chains, further lowering wages and damaging consumption. Moreover, evidence against the Environmental Kuznets Curve hypothesis has pointed to a monotonic relationship between income growth and pollution, further leading to environmental externalities being transferred from high- to low-income countries.

A potential way to tackle these challenges is via a targeted liberalization of trade in goods and services with improved environmental performance – i.e. ESTs. In this respect, Sections 4.4 and 4.5 have focused on overcoming barriers to trade in environmental goods and services as defined in Section 4.1.

A reduction of tariffs in environmental goods is expected to stimulate nascent green markets, especially in developing countries where initial tariffs and trade elasticities tend to be higher. Considering the labour-intensiveness characterizing several environmental goods compared to their traditional alternatives, employment opportunities would accrue, particularly in connection with the downstream provision of services and components. Moreover, if coupled with appropriate phasing-out policies for polluting technologies, increased access to environmental goods is expected to facilitate the implementation and decrease the costs associated with circular models. Notwithstanding this evidence, scholars have warned that gains from trade could accrue mostly to developed countries, as their environmental goods would soon outcompete products from nascent green sectors in emerging economies. Moreover, the lack of trade in environmental goods characterizing LDCs has been associated with a lack of capabilities and purchasing power, which cannot be solved by tariff reduction unless measures aimed at market creation are further implemented.

Along with environmental goods, this chapter has paid particular attention to environmental services. Due to their localized modes of supply, the services sector represents the low-hanging fruit for developing countries seeking to participate in global value chains, foster employment, and establish market linkages with their local industry. This is particularly the case for services linked to environmental goods in which developing countries have a revealed comparative advantage in exporting or whose higher levels of intra-industry trade suggest a greater potential for integration into global value chains upon liberalization (see Chapter 3). In this respect, Section 4.5 has showed how the complementarity of environmental services and environmental goods not only increases the potential for innovation and knowledge transfer, but further provides a mechanism to include services along with environmental goods in the negotiation process. In addition, more flexible WTO regulations on services would allow more space to developing countries in shaping their green industrial policy. Yet, due to the difficulty in measuring trade in environmental services and constraints associated with their different modes of supply (see Table 4.6), services have been mostly excluded from the APEC and WTO EGA negotiations. This is further complicated by the conflicting interests characterizing environmental goods and environmental services providers, with the first advocating protectionist measures to favour local manufacturing and the second, benefitting from cheaper imports, fostering the need for localized installation and maintenance services. Environmental services providers are therefore expected to benefit from the removal of tariff and non-tariff barriers, especially those limiting the free circulation of capital and people.

Section 4.6 has provided a focus on EPPs, a category that includes several agricultural and resource-based products in which developing countries maintain a comparative advantage. On the one hand, the inclusion of EPPs in the present WTO EGA negotiations presents several opportunities, including an incentive for emerging economies to join the talks and reducing future switching costs as countries abandon polluting paths of industrialization. In addition, the economic, social, and environmental benefits associated with certified agriculture and aquaculture provide an attractive business case for developing countries, further supported by several case studies. On the other hand, the mercantilist approach adopted by several countries in the negotiations and the lack of harmonized regulations and standards as part of a global system of governance present a major barrier, which adds to the numerous non-tariff barriers already constraining the development and commercialization of EPPs in several developing countries. Moreover, the controversy around EPPs, including about their environmental credibility, should be kept in mind and caution any simplified judgement.

In a nutshell, this chapter pointed to a number of constraints and challenges that deserve further attention if trade in ESTs is to achieve the three-pillar strategy of sustainable development discussed in the introduction to this report (UN, 2005; UNEP, 2011). These constraints call for targeted green industrial policy measures to complement the reduction of tariff-barriers, especially in developing countries and LDCs where several non-tariff barriers still limit participation in ESTs' global value chains. Furthermore, international partnership as enshrined in SDG 17, emerges as an important facilitator to support the participation of developing countries in global ESTs' markets, especially in sub-Saharan Africa where, despite the growing potential of renewable energies and EPPs in countries like Ghana, Kenya and South Africa (Ikiara and Mutua, 2004; UNEP, 2015a, 2016c), multilateral global initiatives have been virtually minimal.

The overview of opportunities and challenges for trade in ESTs, and their implications for developing countries, paints a picture of a complex situation. The next chapter presents a framework for assessing EST impacts along economic, social, and environmental dimensions. Using the SDGs and their targets as a standard of sustainability, five ESTs and their impacts are mapped in relation to their contribution to the targets. This assessment demonstrates a potential framework for evaluating the sustainable development contributions of ESTs for meeting basic needs in developing contexts, and for identifying EST contributions, or hinderances, to long-term sustainable development. Approaching the analysis from the global perspective presents an overview that may be simplified, but still communicates the range of important sustainability aspects that must be considered across all ESTs to deem them "environmentally sound." Relating environmental, social and economic aspects to specific SDGs and targets helps weigh the potential impacts, positive and negative, on local communities and biological and atmospheric processes.

5. Opportunities and challenges of EST trade liberalization II: Sustainability assessment of selected ESTs

To gain a full picture of opportunities and challenges for developing countries related to the liberalization of trade in ESTs, it is necessary to not just consider macroeconomic aspects of global trade, but also take a closer look at the micro level and assesses implementation-level environmental and social impacts of the identified ESTs. To this end, a framework for the sustainability assessment of selected ESTs is presented and discussed in this Chapter.

5.1. Sustainable development from earth-system perspective

The Brundtland definition is most widely cited to conceptualize sustainable development. It states: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). The remainder of the definition is not often presented, but provides essential framing for the perspective applied in this analysis. It describes that within sustainable development there are two important concepts: 1) basic needs and 2) the environment’s ability to meet present and future needs, as a limiting force on the state of technology and social organization (WCED, 1987). Both human needs and the earth as a limiting force must be considered fundamentally when assessing the potential for sustainable development. The concept of the three pillars, or triple-bottom-line, of sustainable development places the same weight on the economy, environment and society, and ignores the importance of these framing conditions. Improving this logic, the three pillars are now increasingly thought of instead as three dimensions, which influence and affect each other in different ways. Griggs et al. (2013) therefore propose a nested system of sustainable development dimensions, illustrated in Figure 5.1, which highlights the environment as the prerequisite for all social and economic development. They assert a new definition for sustainable development in the Anthropocene: “Development that meets the needs of the present while safeguarding Earth’s life-support system, on which the welfare of current and future generations depends” (Griggs et al, 2013, p. 306). It is this definition that guides the sustainability assessment performed in this chapter.

The new definition supports the mission of the 2030 Agenda for Sustainable Development. While the Millennium Development Goals focused on social development needs and poverty reduction, they were heavily criticized for their exclusion of environmental considerations. The SDGs therefore include goals with a focus on the environment and climate change. Preventing the catastrophic effects of climate change will also depend on following through on the emission targets set out in the Paris Agreement (UNFCCC, 2015) and making extreme changes in energy, infrastructure, transport and finance flows (IPCC, 2018). Folke et al. (2016) have supplemented the nested perspective of sustainable development dimensions by mapping the SDGs upon

Figure 5.1: The nested paradigm of sustainable development (based on Griggs et al. 2013)

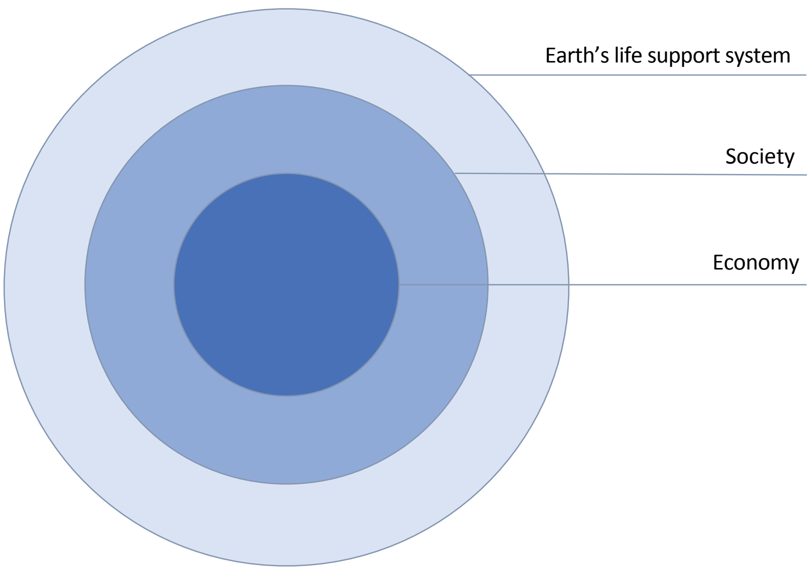


Figure 5.2 The 17 Sustainable Development Goals positioned in relation to the biosphere foundation and the safe operating space for humans on Earth (Folke et al. 2016)

them, shown in Figure 5.2. Such positioning demonstrates the varying levels upon which certain goals influence sustainable development. It should be noted that goals are not fixed at the level at which they are placed in Figure 5.2, and many can be considered to cut across more than one level. This further supports the value in considering sustainable development aspects not as pillars, but as interacting dimensions where the biosphere is the bedrock upon which sustainable social and economic development can take place. The design and approach of the sustainability mapping described in the next sections is based on this line of reasoning.

5.2. Sustainability assessment approach

Following the earth-system perspective of sustainable development, a framework was developed to map and analyse the sustainability aspects of five ESTs. This framework is an adaptation of that developed in Knudson, Aspen and Hermansen (2015) for the identification of environmental goods for nomination to the WTO EGA. Using a methodology based on multi criteria decision making tools and management, they developed an assessment framework to evaluate and identify environmental goods with specific relevance for meeting basic needs in developing countries. Based on study objectives, a set of criteria were operationalized to assess a group of environmental goods (Knudson, Aspen and Hermansen, 2015).

The framework follows three steps:

(1) Defining the objectives and criteria of the assessment

In line with the objectives of the report to enhance global understanding of the implications of the liberalization of EST trade and provide support to developing countries to assess related opportunities and challenges, a set of criteria was selected to assess the sustainability aspects of ESTs across the dimensions of environment, society and economy. As the internationally agreed upon framework for sustainable development, the SDGs provide targets that specify priorities and indicators related to improving social impacts, environmental protection and economic security and were therefore chosen as sustainability criteria for the assessment. They are designed to fit together as an interconnected system of priorities, that together make up the path toward sustainable development. An important consideration is therefore to recognize interactions between different targets, goals and sustainable development dimensions. The complete list of SDG targets is available in Annex 9.

The interconnected nature of the SDGs consists of both positive interactions, i.e. synergies, in which progress toward one goal or dimension supports the achievement of another, and negative interactions, i.e. trade-offs, where improvement toward one negates progress on another (ICSU, 2017). Such interactions are complex because a change targeted at one goal cannot only change progress on another goal, but also create a feedback process where the change in the second goal affects the initial goal that was targeted. For instance, targeting poverty might create improved health, and improved health might improve a person's ability to work and get out of the poverty trap. If one adds not only two interconnected goals with feedback loops, but three or more, the system gets complex very fast. An example of such can be seen in the sustainability assessment of water filters. At the first glance water filters seem to be mainly connected to positive health impacts related to clean water access. However, it becomes obvious that such health impacts are positively correlated with other social issues such as poverty and education - areas where improvements in turn improves health. To complicate matters further, these feedback mechanisms can be indirect in the sense that improved health leads to improved educational performance, leading to reduced poverty with improved work opportunities, which finally can lead to increased health again through the increase in available resources. Needless to say, it is difficult to describe such complex interconnections in a clear manner in a short amount of space. This analysis therefore focuses on simpler connections to illustrate SDG interaction, but the reader is urged to reflect on plausible broader and more complex feedback loops like the one described above.

Figure 5.3: The UN Sustainable Development Goals

(2) Selecting ESTs for the assessment

Using the list of the top-10 EST-EGs with clearer environmental end-use traded in 2016 (presented in Table 3.5), four environmental goods were selected for further sustainability analysis across the product categories of APC, WMWT, SHWM and RE. To represent all five of the project's focused product categories, natural fibres has also been selected to represent the EPP category. They are, presented in the order of largest trade value across the product categories: solar PV cells (RE), filtering machinery for water (WMWT), waste incinerators (SHWM) and filtering machinery for gases (APC). Each of these technologies is also listed on the WTO's 153-list, the APEC 54 list, and the OECD list of environmental goods. The fifth EST represents the category of EPPs and a sustainability analysis of hemp and flax textiles benefits compared to cotton textiles will be presented. Although there are many limitations to such comparative sustainability assessments that are a concomitant part of EPP evaluations, this example is included based on the export potential that natural fibres have for developing countries. Table 5.1 lists the selected ESTs.

One should note that the assessment could have been applied to any EST. The five chosen were selected to demonstrate the assessment framework across the product categories selected in the report. By selecting a range of different technologies, this report's assessments provide insight into the different sustainability aspects related to each, and model what further assessments could look like.

(3) Assessing the selected ESTs across the sustainability criteria

For an overview of their sustainable development contribution, the selected ESTs are mapped across the dimensions of sustainable development and the 169 SDG targets. The results of the assessment are summarized in a table for each EST. Within each table, sustainability contributions are categorized across sustainable development dimensions. Additionally, there is a distinction made between sustainability contributions and limitations. The 'contributions' row (+) relates to what makes the technology environmentally sound, while the 'limitations' row (-) refers to additional considerations that the assessment should take into account. Limitations may relate to, for example, considerations of local culture, the need for additional regulation or finance to support the uptake of an EST. It should be mentioned that the tables and discussions do not cover every SDG for each EST, but instead present those for which the technology may have the most impact. It is further important to underscore that the qualitative nature of our approach only indicates potentially important impacts, while follow-up studies should include quantitative studies adopting a life-cycle perspective to allow for more robust conclusions.

The following sections provide a sustainability assessment of the five selected ESTs and their implications for sustainable development within local communities in developing countries. Besides the challenges mentioned above, there are two further limitations to this approach. Firstly, taking the global approach helps to provide a wider scope on the benefits of clean technologies and services. However, local impact varies heavily across communities, regions and nations, depending on capacity needs, cultural traditions, and the surrounding natural and political environments. At the global level, therefore, trends, needs and impacts are likely oversimplified, and focused case studies, such as the ones conducted by UN Environment (2015a; 2015b; 2016a; 2016b), can help to provide data that is more specific to individual regions and communities. Secondly, some of the ESTs analysed are subparts of larger technologies which target specific development issues. Therefore, the discussions in the analysis are often at an aggregate level, which might obscure the relevance of the EST from the perspective of the reader. The implicit assumption to understand here is that the EST in question is an essential part of the overall technology.

Table 5.1: ESTs selected for sustainability assessment

EST	HS code and description	Product category	Global trade in HS heading(s) in USD billion 2016[63]
Solar PV cells	HS 854140 Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes	RE	95.61
Filtering machinery for water	HS 842121 Filtering or purifying machinery and apparatus for liquids: for filtering or purifying water	WMWT	13.56
Waste incinerators	HS 851410 Furnaces and ovens; electric, for industrial or laboratory use, resistance heated (also traded within HS 851420 and HS 851430)	SHWM	2.95
Filtering machinery for gases	HS 842139 Filtering or purifying machinery and apparatus: for gases	APC	37.55
Natural fibres	HS 530210 Hemp; raw or retted, but not spun HS 530820 Yarn; of hemp HS 530620 Yarn; of flax, multiple (folded) or cabled HS 530110 Flax; raw or retted, but not spun HS 530121 Flax; broken or scutched, but not spun HS 530919 Fabrics, woven; of flax, containing 85% or more flax, other than bleached or unbleached HS 530610 Flax yarn, single HS 530929 Fabrics, woven; of flax, containing less than 85% flax, other than unbleached or bleached HS 530911 Fabrics, woven; of flax, containing 85% or more flax, unbleached or bleached 530129 Flax; hackled or otherwise processed, but not spun HS 530921 Fabrics, woven; of flax, containing less than 85% flax, unbleached or bleached	EPP	84

Footnotes:

63. From trade analysis performed in Chapter 3. The trade analysis for natural fibres is provided in Annex 10.

5.3. Sustainability assessment of solar photovoltaic cells

Energy is essential for meeting basic human needs and is the basis for many economic development activities. As the global population continues to grow and is accompanied by rapid economic development, urbanization and a rising standard of living, the demand for energy is expected to increase by 1.5-3 times by 2050 (Shahsavari and Akbari, 2018; Dincer and Zamfirescu, 2011). Recognizing that two-thirds of global greenhouse gas and 80% of CO2 emissions result from current energy production (IEA, 2015), the increase in energy demand provides a grim outlook for climate change. For the first time in history, greenhouse gas emissions from developing countries now take the lead over those from developed nations (IEA, 2015). Furthermore, the aggregate CO2 emissions of developing countries is greater than that of the developed and transition economies (Pfeiffer and Mulder 2013). It is for these reasons that renewable energy will play a vital role in the future well-being of the planet and its people.

As demonstrated in Chapter 3, trade in renewable energy technologies represents the largest share of EST-EGs traded globally at roughly 36%. Solar PV cells (HS 854140) have been selected for sustainability analysis for their large trade value (USD 95 billion in 2016) and growing markets in the global south (UNEP, 2014). Solar PV cells are traded under HS code 854140, a code that also includes LEDs and other photosensitive semiconductor devices. Because of the wide category, the representativeness of the HS code for trade in solar PV has been challenged. Previous studies have stated, however, that using HS 854140 as a proxy for solar PV in global trade analyses is unavoidable (UNEP 2014), and it is therefore used in this study as well.[64]

Solar photovoltaic cells

HS 854140 Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes

Solar energy technologies are those that capture energy from the sun for conversion into useful energy forms. Applications of solar energy are growing, especially in developing countries. According to Shahsavari and Akbari (2018), “solar energy systems are the most economical solution for the mini-grid and off-grid electrification in rural or remote areas and isolated communities…” (p. 278). There are two main types of solar energy systems, concentrated solar power (CSP) and PV power. CSP systems use hundreds of mirrors to concentrate solar energy to produce heat or electricity. CSP technologies are difficult to track on a global scale due to multiple end-uses associated with their 6-digit HS coding for component parts. For this reason, this report focuses on solar PV cells, which directly convert the sun’s energy into electricity for application in meeting energy needs.

Traded under HS 854140, PV cells produce electricity for many uses, including lighting, cooking, heating, refrigeration, crop drying, powering modern technologies and more. PV cells can be used on their own, combined in panels or arranged in large arrays. PV systems can operate in multiple environments where there is no existing energy infrastructure or where connection to the grid is too difficult, inefficient or expensive. They can be arranged in groups as local installations for rural villages disconnected from the central grid, or used singularly to power water pumps, desalination units, hospitals or schools. This makes them an effective and reliable energy source in many developing communities. The impact of solar PV cell implementation in developing countries is evaluated in terms of its contribution to sustainable development.

Footnotes

64. For further discussion of HS 854140 as a proxy for solar PV, see UNEP (2014).

5.3.1. Environmental aspects of solar PV cells

Growing energy demand and resulting emissions from its production through traditional fossil-fuel based sources are a dangerous combination. Renewable energy technologies, including solar PV panels, are essential in reducing emissions and slowing the negative effects of climate change. Emissions reduction targets in the Paris Climate Agreement and in SDG 13 on Climate Action clearly dictate the need for a reduction in energy-related emissions. PV systems can save 0.53 kg CO2 emission for each Kilowatt-hour of electricity generated, resulting in a reduction of 69–100 million tons of CO2 by 2030 (Shahsavari and Akbari, 2018). Additionally, it is estimated that PV systems could reduce nitrogen oxide and dioxide emissions by 68,000–99,000 tons (Ibid.). In addition to a reduction in the greenhouse gas emissions from traditional energy production, solar energy also cuts the fly ash that results from burning coal, and the indoor air pollution and release of non-methane volatile compounds from biomass burning, which are both heavily dependent on energy sources in developing countries. The health effects of these reductions will be discussed further in Section 5.3.2, but represent a powerful synergy between an abatement in emissions and air pollution and a reduction in disease.

The replacement of existing energy sources with renewable technologies contributes to a reduction in biomass burning and the deforestation and biodiversity loss it causes. To provide an idea of scale, in developing countries, 56% of total primary energy use comes from traditional biomass (Shahsavari and Akbari, 2018). To break it down further, 80% of the population in sub-Saharan Africa uses biomass as their main energy source, and 1.9 billion people in Asia rely on biomass for cooking (IEA, 2016). SDG 15 on life on land specifically targets the negative environmental impacts of excessive biomass harvesting through, for example, targets 15.2 (reducing deforestation) and 15.5 (biodiversity loss). Furthermore, the collection and burning of biomass is most often conducted by women and children, creating negative impacts on health, education and other social aspects, discussed further in the next section. The replacement of biomass burning with renewable energy technologies results in another synergy between climate action (SDG 13), biodiversity preservation (SDG 15), health (SDG 3), education (SDG 4) and gender equality (SDG 5).

Although solar PV cells provide energy access with greatly reduced climate impacts compared to traditional sources, the use of toxic compounds, explosive gases and corrosive liquids in their production must also be acknowledged. Strict control of cell and component production lines must be enforced, especially in the developing country markets where they are increasingly being produced (UNEP, 2014). Without regulation, these compounds can harm the health of workers (SDG 3) and disturb land and water ecosystems (SDG 15 and 16).

5.3.2. Social aspects of solar PV cells

As a bedrock for meeting basic health, safety and development needs, it is crucial that renewable energy systems are established in developing economies. Some of the environmental impact reductions related to solar PV panel implementation were introduced above. The connections between emission and air pollution reductions (SDG 13) and ecosystem protection (SDG 15), and the larger social implications related to society level SDGs are discussed in this section.

A logical starting point in the society dimension is SDG 7 on clean and affordable energy. As a renewable energy technology, solar PV cells contribute to increasing the share of renewable energy in the global energy mix (target 7.2). Their application flexibility and off-grid potential assists in ensuring universal access to modern energy services (target 7.1). Fluctuating PV supply makes it necessary to some degree to also use conventional energy supply which then is as clean as possible. Increasing solar PV installations and capacity additions in developing countries are likely to continue their rise as costs fall and technological capacity builds (UNEP, 2014). This growth can be compounded by an increase in enabling policies and enhanced international cooperation for renewable energy access (target 7.A) and will facilitate the expansion of infrastructure and technology for reliable and clean energy services and access (target 7.B).

The societal impacts of this increase help reduce poverty levels through improvements in health (SDG 3), education (SDG 4) and gender equality (SDG 5). Without access to electricity, many households in developing countries depend on biomass, charcoal, kerosene and other unsustainable fuels for their lighting, cooking and heating needs. As mentioned, dependence on biomass contributes to deforestation and ecosystem disruption (SDG 15). The indoor burning of solid fuels produces dangerous smoke and indoor air pollution, which causes and exacerbates disease, including respiratory illnesses and cancers, and has been linked to the deaths of 3.8 million people in 2016 (WHO, 2018). These deaths are disproportionately distributed across women and children in developing countries (Ibid.). A reduction in indoor cooking fuels, replaced by solar energy, therefore can help reduce global and child mortality from air pollution, communicable and non-communicable diseases (targets 3.2, 3.3, 3.4 and 3.9). Access to health care facilities (target 3.8) can also be increased through solar energy provision in hospitals and clinics for lighting and powering needed technologies.

Lacking access to reliable energy sources limits activities of daily life, especially for women and children. Women and children are those most often responsible for the collection of biomass cooking fuels, a timely activity that takes children out of school and prevents women from employment outside the household (Otte, 2013). Cultural expectations and practices must also be considered, but it can broadly be acknowledged that access to reliable electricity can positively support children's access to school and educational activities (targets 4.1, 4.2, 4.5 and 4.6) by reducing their time spent on household chores and the related health risks, and providing necessary lighting and heating for successful learning. Similarly, access to solar energy also helps to promote gender equality and empower women and girls by reducing their time spent collecting fuel, cooking and breathing dangerous fumes (target 5.4), allowing them to go to school and support local industries. These results indirectly support a systematic reduction in poverty (SDG 1) by creating an educated workforce, improving abilities to work outside the home, reducing gender inequalities and establishing industries powered by renewable energy. Such economic improvements are discussed further in Section 5.3.3, but powerfully illustrate the interactions between SDGs and their achievement.

In addition, the many applications of solar PV cells support other social development aspects. The growth in solar PV capacity can support access to clean water and sanitation (SDG 6) and an increase in agricultural production (SDG 2) through solar-powered water pumps. Food availability (SDG 2) can be increased and food waste (SDG 12) reduced with refrigeration units, food dryers and greenhouses powered by PV cells (Shahsavari and Akbari, 2018).

The synergy between an increase in renewable energy, the resulting decrease in harmful emissions and positive improvements in social aspects has been introduced. These positive interactions support the achievement of environmental, social and economic sustainability. Barriers to the uptake of solar PV panels must also be discussed, however, in terms of their limitations, and potential trade-offs. First, many are unaware of the health impacts of burning traditional fuels that have been depended upon for centuries. Education of both the health and environmental damages they cause could support a transition to renewable sources. Further, limited access to long-term finance and investment can limit both small- and large-scale installations and has been shown to be a large barrier specifically for solar energy in developing countries (Shahsavari and Akbari, 2018). Compounded with lacking technical knowledge and skilled workers, these obstacles prevent the widespread installation of solar PV (Ibid.).

5.3.3. Economic aspects of solar PV cells

The economic aspects of solar PV cells cross dimensions of both international trade and local applications. UN Environment (2014) discusses trends in South-South trade in solar PV across South-South and global value chains. It suggests that with growing import demands, there may be opportunities for developing countries to develop their own manufacturing sectors in parts of the solar PV value chain (e.g. module assembly or component parts), rather than in other highly-competitive upstream market sectors. Manufacturing development and other downstream services (e.g. installation, operation and maintenance) could bring employment opportunities to local markets (SDG 8, targets 8.2 and 8.5) (UNEP, 2014). As mentioned in the discussion of social aspects, access to reliable electricity can also help to support the development of other industry sectors (target 8.2), bringing jobs and capital to local communities. The looming factor of finance and banking services is an essential component of local manufacturing and industry development, and may be another obstacle to its implementation.

In terms of SDG 9, solar PV installations can help to establish resilient and inclusive infrastructure, industrialization and innovation. New solar capacity additions in developing countries rose by more than 60% in 2012 (UNEP, 2014), showing growth in their implementation. Transitions from traditional dirty energy sources to renewables support the development of sustainable energy infrastructure in both on- and off-grid applications (target 9.1). As discussed previously, the use of solar PV in off-grid applications can deliver energy for basic needs and education to communities that have been without access. On a larger scale, enabling policies and government support are necessary to develop and implement sustainable infrastructure that does not depend on technologies from the West's polluting past (targets 9.A and 9.B). Forward-looking policies and incentives can drive the sustainable upgrades of existing energy infrastructure and manufacturing sectors (target 9.4).

Furthermore, as urbanization continues its expanse, solar and other renewables provide an opportunity for sustainable and innovative city development (SDG 11, target 11.3). Electricity from solar PV delivers improvements in lighting, cooking, heating, refrigeration, education and health care, which can support the growth of communities that meet the basic needs of inhabitants (target 11.1).

Although the cost of PV cells is falling, installation costs are still seen as the largest barrier to their uptake in developing countries (Shahsavari and Akbari, 2018). Additionally, solar PV systems have the lowest efficiency compared to other renewables (Evans et al, 2009). This is due to their varying efficiencies based on environmental variables like solar radiation, ambient air temperature, wind and humidity. Lower efficiency and higher costs than traditional energy sources, along with unawareness of the environmental and health externalities caused by burning solid fuels, make the switch both unappealing and out of scope for many rural communities. This of course varies based on location and levels of economic development, but lowered technology costs and/or increased traditional fuel costs could drive their uptake.

Solar PV cells represent an EST-EG that provides strong sustainability across environmental, social and economic dimensions. Although barriers in local finance, capacity and awareness may slow implementation in some rural communities, the flexibility and wide range of solar PV applications makes them a means for basic needs delivery across large and small scales. An increase in capacity additions in developing countries documents their current growth – growth that can support improved health, education, safety and daily life. Table 5.2 presents the assessment overview table for solar PV cells.

Table 5.2 Sustainability aspects of solar PV cells

EST	Solar photovoltaic (PV) cells HS 854140 Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes
Product category	Renewable energy (RE)
Description	Solar PV cells directly convert the sun's energy into electricity. They can be used on their own, combined in panels or arranged in large arrays, and can operate in multiple environments where there is no existing energy infrastructure or where connection to the grid is too difficult, inefficient or expensive.
Use	Used to provide renewable energy powered electricity for many applications, including lighting, cooking, heating, refrigeration, crop drying, powering modern technologies and more.

Evaluation	Environmental	Social	Economic
+	• Reduce GHG emissions, NMVOCs and other polluting substances compared to fossil fuel sources • Solar energy is abundant and renewable • Reduce biomass burning and deforestation	• Increase share of renewables in global energy mix • Provide reliable access to energy to grid and off-grid systems • Reduce health problems related to indoor air pollution • Increase access to health care facilities with electricity and other modern technologies • Reduce time spent collecting solid fuels and breathing burning fumes (majorly women and children) • Increase access to education, community safety	• Development of energy infrastructure • Employment related to growing solar markets • Provides renewable energy for cities and communities
-	• Compounds, gases and liquids used in production can be dangerous and harm local ecosystems and worker health if not properly managed	• May resist change from traditional sources, or lack investment for solar technology • Lower efficiency and higher costs than traditional sources	• High installation costs • Can be difficult to secure access to finance or investment sources
SDGs & targets	SDG 13 and Paris Agreement emissions reduction targets 15.3 reducing deforestation, 15.4 biodiversity loss	7.2 increase RE 7.1 universal energy access, 7.A international cooperation for RE, 7.B energy technology and infrastructure 3.2 reduce childhood mortality, 3.3 reduce communicable diseases, 3.4 reduce non-communicable diseases, 3.9 reduce deaths from hazardous chemicals 3.8 universal health care access 4.1 and 4.2 education for all, 4.5 eliminate gender discrepancies in education, 4.6 all youth are literate, 5.4 recognize value of domestic work	9.1 develop reliable and sustainable infrastructure, 9.4 upgrade and retrofit infrastructure, 9.A sustainable infrastructure development in developing countries, 9.B domestic technology development 8.2 increase economic productivity, 8.5 achieve full employment and decent work 11.1Access to adequate, safe housing with basic services, 11.3 inclusive and sustainable urbanization

5.4. Sustainability assessment of filtering or purifying machinery for water

Filtering machinery for liquids other than water (HS 842129) was identified in the trade analysis as another highly traded EST-EG (2016 global trade value of USD 15.21 billion). Filters for water (HS 842121) had a smaller traded value, but were selected for the sustainability assessment due to their essential use in water treatment and management in developing countries. Many of the sustainability aspects discussed in this section, however, are also relevant for other liquid filters.

Water filters

HS 842121 Filtering or purifying machinery and apparatus for liquids:

for filtering or purifying water

The filters and purifiers traded under HS heading 842121 vary widely in terms of technical sophistication and contextual applicability. Some are designed for complex industrial water filtration systems and others for household use. Despite their various applications, these goods have the same purpose: filtering and purifying water. This is a task of paramount importance in a world where 80% of wastewater is discharged without treatment, creating adverse environmental, social and economic impacts (WWAP, 2017). A selection of key impacts and their relevance to the SDGs is outlined in this analysis. In line with recommendations from the International Council of Science, focus is placed on interactions between the SDGs to highlight potential synergies and trade-offs (ICSU, 2017).

5.4.1. Environmental aspects of water filters

Water resources are a core aspect of sustainable development, which is demonstrated by its inclusion as a separate SDG. The aim of SDG 6 is to *ensure availability and sustainable management of water and sanitation for all*. In the list of targets to reach this goal, target 6.3 specifies the importance of reducing water pollution and increasing wastewater treatment, recycling and reuse. Such pollution occurs from human activities like agriculture, industry and sewage which spill heavy metals, pathogens, nutrients and other contaminants (Corcoran et al, 2010).[65] While significant progress has been made to abate pollution the last two decades, there is still a long way to go (WWAP, 2017). Findings indicate that 1.8 billion people drink faecally contaminated water each year (Bain et al, 2014). Water pollution is not only a problem for humans, but also has negative effects on the environment. SDG target 6.6 reflects this and aims to restore freshwater ecosystems. Between 1970 and 2012, the biodiversity in freshwater bodies has decreased by 81% - more than for any other type of habitat (WWF, 2016). Alongside habitat change, overexploitation, invasive species and pollution have been other contributing factors in ecosystem disruption, and are mentioned in relation to 12% of threatened species cases (Ibid).

SDG 14 focuses on the conservation and sustainable use of the oceans and their resources. It is closely connected to SDG 6 and target 6.3 of wastewater reduction. Oceans are the final destination of most untreated wastewater, and therefore suffer many of the same adverse effects as freshwater bodies (WWAP, 2017). A particularly salient problem is the increasing amount of phosphorus and nitrogen runoff from agriculture. In coastal areas with limited water circulation, phosphorus and nitrogen overload cause eutrophication, and, ultimately, conditions which cannot sustain aquatic life. Such “dead

Footnotes

65. See Corcoran et al. (2010) for an extensive overview of contaminants and their sources.

zones" are expanding and were estimated in 2008 to already cover over 245,000 square kilometres (Diaz and Rosenberg, 2008). While the most effective solution to this problem would be to reduce excessive use of fertilizer in agriculture (Foley et al, 2011), recovery of phosphorus and nitrogen from wastewater through the use of filters and other technology is starting to become a viable addition to such mitigation efforts (Sengupta et al, 2017; WWAP 2017).

Further, untreated wastewater is also detrimental to the achievement of other environmentally focused SDGs. In relation to life on land (SDG 15), plants and animals in terrestrial ecosystems depend on clean water resources and often exist in close symbiosis with freshwater ecosystems. Negative effects on one ecosystem therefore affect the other, highlighting indirect effects and the interdependence between SDG target 6.6, SDG 14 and SDG 15. For instance, algae bloom as a result of eutrophication, which affects both fresh and salt water bodies, and can also poison terrestrial animals through release of toxins into their drinking water (Carmichael, 2001). SDG 13 on climate change also depends on wastewater treatment, as methane and nitrous oxide emissions from decomposing organic material exacerbate climate change. Although these emissions have a modest contribution to global greenhouse gas emissions, they are increasing (IPCC, 2015, p 787).

5.4.2. Social aspects of water filters

Poverty (SDG 1), hunger (SDG 2) and health (SDG 3) exist in an interdependent relationship which is influenced by the availability of clean water and sanitation (SDG 6). Untreated wastewater disproportionately affects the global poor (UNICEF and WHO, 2015) as decent water access is associated with socioeconomic status, and lack of water in turn makes it difficult to improve one's living conditions. For instance, polluted wastewater inhibits the ability to grow food (WWAP, 2015). This exacerbates health problems related to malnutrition, which is a barrier to work participation and education. Another significant challenge emanates from the close connection between clean water and health. Target 3.3 acknowledges this connection by emphasizing the importance of reducing water-borne diseases by 2030. It is estimated that 842,000 annual deaths are linked to diarrheal disease caused by lack of safe water, hygiene and sanitation. Of this number, 361,000 deaths are of children under the age of five (WHO, 2014a). Unsafe water sanitation and hygiene are one of the major risk factors for death in low-income countries (WHO, 2009). It is estimated that filtering and safe storage of water could reduce diarrheal morbidity by as much as 45% (Wolf et al, 2014). These figures do not include non-lethal cases, which can also be extremely serious and keep people from living functioning lives.

Clean water is also indirectly connected to education (SDG 4). The improved health effects of clean water have been shown to improve school attendance rates and performance (WWAP, 2017). Additionally, diarrheal diseases can cause lethargy and anemia, which makes it more difficult for children to focus in the classroom (Baird et al, 2016). Since diarrheal disease is closely linked to unsafe water, sanitation and hygiene (Prüss-Üstün et al, 2014), improved water treatment could tackle this issue at its source.

Local and sufficient access to clean water is furthermore an important contributor to gender equality (SDG 5), since it is mainly women who are responsible for fetching water in developing countries (UNICEF and WHO, 2012). In some sub-Saharan areas, this task can amount to two to four hours of work per day (Pickering and Davis, 2012). This can have negative effects on women's participation in local communities, cause increased exposure to violence in politically unstable regions, and may decrease school attendance of girls (Nauges and Strand, 2011; UN Women, 2012). While general access to water is the most direct way to solve this problem, use of water filters and purifiers might also increase access by rendering contaminated sources drinkable.

5.4.3. Economic aspects of water filters

Without access to fresh water, social and economic systems would collapse. This reflects the insight of Griggs et al. (2013), that sustainable development requires safeguarding earth's life-support systems. Freshwater resources are included as one of the nine planetary boundaries of Rockström et al. (2009). Passing any of these boundaries implies risk of non-linear, abrupt changes with potentially catastrophic consequences. This global and long-term perspective is important to keep in mind when discussing economic sustainability, to avoid interpreting economic sustainability merely as local and short-term economic growth. SDG target 8.4 focuses on the connection between economic and environmental sustainability, stating that economic growth must be decoupled from environmental degradation.

While economic growth and environmental sustainability may be at odds in some cases, there is ample opportunity for developing countries to improve economically while implementing proper water management. Interventions to improve water quality and access have shown to be especially cost-beneficial in low-income countries (Prüss Üstün et al, 2016). This is because these countries experience the most severe effects from mismanaged water resources, exemplified by some of the negative social and environmental effects outlined in the two previous sections. The impacts that improved health, education and environment have on productivity and participation in the economy, create a five to six-fold return of every dollar invested in water supply, quality and access (Haller et al, 2007). In addition to mitigating negative effects, exploiting wastewater as an economic resource could potentially bring further economic gains. Retrieving nutrients, energy, metals and other valuable inorganic compounds is likely to be increasingly profitable as the world transitions to a more circular economy (WWAP, 2017). Industry innovation (SDG 9) will be an important part of this transfer, as new technical solutions and business models are an essential part of making such retrieval economically viable.

While technologies traded under the HS 842121 heading are not an all-encompassing solution to the wastewater challenges mentioned above, water filters on both small and industrial scales represent a key part. As has been seen, these challenges are associated with environmental, social and economic sustainability, that permeate the entire spectrum of the SDGs and 2030 Agenda. It is therefore a promising trend that the markets for these goods are expanding (UNEP, 2014), and especially that they rank high in developing countries' EST trade portfolios. Table 5.3 presents the overview of water filters.

5.5. Sustainability assessment of waste incinerators

Waste is an inevitable product of increasing population and economic activities on earth. Waste, and its extremely large quantity, is one of the main challenges to be addressed to safeguard the population from its negative effects. It is estimated that global waste generation will double by 2025 to over 6 million tons per day, with the rates expected to peak until the next century (World Energy Council, 2016). In this regard, waste incinerators can be helpful to recycle and sustainably manage waste. Different types of waste incinerators are traded under HS headings 851410, 851420 and 851430. Technologies under HS 851410 had a global trade value of USD 2.95 billion in 2016.

Waste incinerators

HS 851410 Furnaces and ovens; electric, for industrial or laboratory use, resistance heated

The wide product headings must be noted in the analysis of the waste incineration technologies they contain. The large trade values can likely be attributed to the many types of electrical furnaces and ovens traded under the codes. Nevertheless, all three headings have been included in the WTO, OECD and APEC lists of environmental goods. HS 851410 has therefore been selected in this study to represent the product category of solid and hazardous waste management.

Table 5.3 Sustainability aspects of water filters

EST	HS 842121 Water filters and purification machinery and apparatus
Product category	Wastewater management and water treatment
Description	These ESTs consists of filtering or purifying machinery and apparatus for liquids for filtering or purifying water. It includes machinery and apparatus such as: small handheld water filters, chlorination and other systems for provision of safe drinking water and larger and more complex industrial filters, UV purification and other systems for wastewater management
Use	Used to mitigate adverse effects from untreated wastewater

Evaluation

	Environmental	Social	Economic
+	• Reduces water pollution and increases accessibility of clean water • Less damage to oceanic and terrestrial biodiversity • Lower GHG emissions from wastewater	• Reduces waterborne diseases (842 000 deaths are linked to diarrheal diseases from lack of safe water, sanitation and hygiene) • Improves school attendance and performance due to improved health • Enable increased gender equality as women are usually responsible for retrieving clean water	• In developing countries every dollar invested in water supply, management and access yield a five to six-fold return on investment • Retrieving nutrients, metals and other valuable inorganic compounds from wastewater is a promising opportunity from a circular economy perspective • WMWT reduces impact of increased economic activity
-	• The production of water filters cause pollution and resource extraction	• Can be too expensive and inefficient to be employed in poor neighborhoods	• While the long-term economic benefits of WMWT are clear, installation and operation of such systems can represent a significant short-term cost
SDGs & targets	6.1 Water access 6.3Water pollution reduction and increased wastewater treatment 6.6 Restore freshwater ecosystems 14.1 Reduce marine pollution, including nutrient pollution	3.3 Reducing waterborne disease	8.4 Decoupling economic growth from environmental degradation

Waste incineration is quickly expanding as a means to destroy waste, reducing the mass and volume of residues and recovering energy content from unrecyclable materials that have a significant heat value (Hung et al, 2011). Today, more than 2,200 thermal treatment plants are active worldwide, with the capacity to destroy about 300 million tons of waste per year (Boyd and Schroeder, 2017). However, it is a very controversial process, and many people believe that waste incinerators reduce the incentives to decrease waste generation and move towards a zero-waste society. Furthermore, various waste-to-energy technologies exist for this process. The choice of technology depends on different factors and each region should perform a comprehensive analysis to choose the best technology. Sanitation and waste management services are also important to bring the necessary technical knowledge and engineering capacity. The impacts of waste incinerators used in developing countries are examined in terms of their contribution to the SDGs.

5.5.1. Environmental aspects of waste incinerators

The excessive amount of waste in the environment has resulted in many health and environmental issues that threaten earth's life support system. Waste incineration is a method that helps treat waste and especially hazardous wastes. Waste incinerators are considered to be a useful tool to reduce the quantity of waste on land and oceans (targets 15.1, 14.1, 14,2, 14,3) and Lenkiewicz (2016) considers solid waste management as a key to delivering the SDGs. Waste incinerators could potentially reduce the amount of waste on land, a vital step in reducing acid rain and ocean acidity to preserve the ecosystem. In this regard, these technologies could potentially help to achieve SDG 15 and SDG 14. However, it is important to consider that the incineration process itself releases a variety of pollutants based on the composition of waste. There are two types of ash from the incineration process. Bottom ash comes from the furnace and is mixed with slag, while fly ash comes from the stack and contains components that are more hazardous. In municipal waste incinerators, bottom ash is approximately 10% by volume and approximately 20 to 35% by weight of the solid waste input. The improper disposal of ash can lead to environmental degradation. Therefore, it is necessary to find a way to dispose the ash properly. The effectiveness of a waste incineration process depends on the type of waste and the technology that is chosen for the process. To reduce negative environmental externalities and the risk of environmental accidents in using waste incinerators, it is vital to utilize upgraded technologies.

There are many concerns regarding the use of waste incineration in the case of hazardous wastes. The combustion process emits toxins that can adversely affect air pollution in developing countries. As a result, it is very important to set safety codes and standards and monitor the incineration process. Outputs to the environment from the process must be assessed carefully to reduce adverse effects as much as possible. In addition, developing countries should select the most suitable area to establish waste incineration plants based on careful environmental, sociological and economic criteria. A case study in Cameroon shows that to reduce this pollution it is important to use state of the art incineration processes, and the incinerator plants should be placed carefully. This reduces the risk of health damages due to emissions from the incineration plant (Mochungong, 2012).

5.5.2. Social aspects of waste incinerators

Waste incineration is a viable option for the disposal of municipal solid waste and the generation of energy. Electricity can be produced from waste through direct combustion, and the released heat is used to produce steam to drive a turbine (World Energy Council, 2016). As explained in in the assessment of solar PV, the provision of affordable and clean energy contributes heavily to meeting basic needs and increasing the standard of living (SDG 7, targets 7.1, 7.A, 7.B). The contribution of electricity from incinerators has a limited potential however, and should therefore only be part of a nation's general strategy for energy generation.

Additionally, because waste incinerators are used on an industrial or municipal scale, they are not appropriate for rural areas where the infrastructure or viable quantity of waste may not exist. One should also note that food waste contains energy contents that can be used to produce bio energy, another clean source of energy (Kim et al, 2003). To gain benefit from the production of electricity and heat from waste via waste incineration processes in developing countries, an efficient distribution network should be installed.

In Shenzhen, an industrial city near Hong Kong in China, the volume of solid waste has increased from 50 tons a day in 1979 to 15,000 tons in 2017. In an accident in 2015, a mountain of construction debris and trash collapsed and killed at least 69 people (Yale Environment, 2017). After this accident, the city municipality decided to increase the number of waste-to-energy incinerators to help people and reduce the amount of waste in the city. Chemical products such as medicines, insecticides and repellents help to reduce the number deaths each year. At the same time, 4.9 million deaths (8.3% of the global total) and 86 million disability-adjusted life years (5.7% of the global total) happen as a result of pollution (WHO, 2004). Shenzen's aim is to reduce this pollution and to produce enough electricity to power roughly 100,000 apartments. Abor and Anton (2008) believe that, especially in resource-poor nations, waste incinerators are helpful. It reduces waste volume, toxicity and reactivity (Klein et al, 2001). This also decreases the opportunity cost of the time spent on collecting fuel in poor and rural areas. Therefore, low-income households can have more time to participate in agricultural activities and provide better food and income (target 1.1, SDG 2). As a result, utilizing waste incinerators for energy production can indirectly contribute to reducing gender inequalities (SDG 5). In poor areas women are responsible for the time-consuming task of collecting biomass fuels, but with the possibility of producing clean electricity from wastes women have more time to go to school. In addition, they are less exposed to dangerous toxicant from traditional fuels with the availability of clean ovens. As a result, they will have better health conditions and more opportunities to be involved in the society (SDG 5).

5.5.3. Economic aspects of waste incinerators

Economic growth can help to drive sustainable development. When this growth is sustained and inclusive, more people can escape poverty as opportunities for full and productive employment expand. Chemicals contribute to national economies to a great extent, but permanent exposure to hazardous chemicals and waste generated from human activities threatens the health of the labour force, which has adverse implications for economic growth. A clear link has been established between poverty and an increased risk of exposure to hazardous chemicals and wastes (UNEP, 2016d). Unfortunately, due to the type of jobs and lack of awareness of negative health effects, the poor suffer from exposure to waste. Waste incinerators can reduce exposure to waste (SDG 8.8) and therefore contribute to sustainable economic growth. Borel-Saladin and Turok (2013) assess the green economy through its core assumption, "that environmental progress cannot be separated from economic growth and development." Although, as a society, we should work to greatly reduce waste, it is also an inevitable side effect of industry and other economic activities. Waste incinerators therefore present a way to create value from waste, and could be part of a circular and green economy that takes a life cycle approach. Waste incineration as a source of heat and electricity production can lead to the development of other industries as well. As a result, it is possible to create more value domestically, directly, indirectly and via implied effects, to foster further development and economic prosperity (targets 8.2, 8.3, 8.2.1). A good example of the cities that create value from waste is Trondheim in Norway. The city municipality converts solid waste to environmentally friendly heat, reducing the significant energy demand for heating which is common in temperate countries.

Waste incinerators can play a role in delivering economic sustainability and motivating sustainable consumption and production (SDG 12). Using them, it is possible to manage chemical and wastes effectively to minimize their adverse impacts on human health and the environment, and to preserve more natural resources (target 12.4). To substantially reduce waste through reduction, recycling and reuse of waste (target 12.5), innovative industry development (SDG 9) is needed to find new and efficient processes and technologies to create value from waste. As a result, these innovations can motivate the development of new green business models to boost the economy of developing countries (targets 9.1, 9.4, 9.5). Research and development in this regard stimulate local economies and markets, and may provide opportunities for related technology exports. This can boost the economy via local opportunities and international trade, demonstrating a positive interaction between SDG 9 and SDG 12. This is a synergy that can broadly be said to exist across ESTs, when they are sustainably produced and managed.

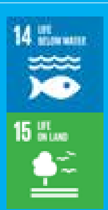
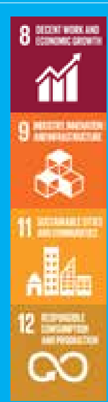
Industry innovations could also address negative aspects of waste incinerators such as harmful toxic emissions as a by-product of the incineration process. Harmful and hazardous emissions produced during incineration are the main barrier to utilizing the process in many developing countries that suffer from air pollution. Another potential barrier is the cost of waste transportation, which depends on the type of waste, since it is difficult to find waste incinerators everywhere. There are also ethical issues regarding waste incineration since developed countries often send their waste to be processed in developing countries. The process is cheaper in developing countries due to the lack of stringent environmental standards and need for income.

To make cities more resilient and sustainable, the negative environmental impact of waste should be reduced (target 11.6). In cities, this depends on municipal policy and management. While the development of policy actions is another large hurdle, when implemented efficiently and with environmental management practices in place, waste incinerators can contribute to a successful waste management system.

This assessment outlines some of the sustainability aspects associated with waste incinerators as a means of destroying waste. Table 5.4 provides an overview of the assessment. Waste incineration processes affect human daily lives directly and indirectly in various ways. These technologies, if used correctly and properly, can potentially contribute to the achievement of the SDGs. The use of incinerators entails social, ethical and economic challenges that should be considered when choosing the best waste management method. A set of safety codes and environmental regulations and standards seems necessary to reduce negative externalities of the incineration process. It is also very important to ensure that current regulations are a sufficient protection against potentially harmful effects of waste incineration plants for workers and people living in the surrounding areas of waste incineration plants. Furthermore, massive utilization of waste incinerators in developing countries may encourage more waste production since incinerators require large volumes of waste to keep the fires burning. As a result, choosing waste incinerators over recycling and waste reduction programmes in developing countries can cause many problems in the long term. The broad HS headings make it difficult to know the specific trade values of waste incinerators. As a means to both destroy waste and create energy, they represent an EST with sustainability and economic potential. However, it is recommended that authorities and decision-makers in developing countries perform a thorough assessment and a cost-benefit analysis regarding waste incinerators. Considering both positive and negative impacts of waste incinerators would be useful to choose the best and the most efficient way to manage waste.

Table 5.4 Sustainability aspects of waste incinerators

EST	Waste incinerators HS 851410 Furnaces and ovens; electric, for industrial or laboratory use, resistance heated
Product category	Solid and hazardous waste management (SHWM)
Description	means to destroy waste, reducing the mass and volume of residues and recovering energy content from unrecyclable materials that have a significant heat value
Use	Used to manage waste and reduce negative environmental externalities caused by pollution

Evaluation			
	Environmental	**Social**	**Economic**
+	• Reduces waste to preserve terrestrial ecosystem • Reduces waste to preserve marine ecosystem and biodiversity	• Has the potential to increase the use of bioenergy • Improved health because of less exposure to waste, it is important to build the plant out of residential areas • It can probably increase economic activities	• Create value from waste, boost innovations and R&D in technology related areas in developing countries, and help their economy to grow. • Waste management facilitate transition to circular economy and a zero-waste society
-	• Increase air pollution in the region	• Building plants in residential areas can affect the people's health adversely.	• It is expensive to install good and efficient waste incineration plants in developing countries
SDGs & targets	 14.1 reduce marine pollution 14.2 sustainably manage marine ecosystem 14.3 minimize the impacts of ocean acidification 15.1 ecosystem preservation	 1.1 eradicate extreme poverty 2.1 no hunger 3.1 reduce maternal mortality 3.2 reduce childhood mortality, 7.1 universal energy access, 7.B energy technology and infrastructure	 8.2 increase economic productivity, 8.5 achieve full employment and decent work 9.1 develop reliable and sustainable infrastructure, 9.4 upgrade and retrofit infrastructure, 9.5 enhance scientific research 11.6 waste management 12.4 waste management 12.5 reduce waste by recycling

5.6. Sustainability assessment of filtering or purifying machinery and apparatus for gases

The utilization of gas filters for industrial, transportation and household purposes improves air quality. Better air quality and less exposure to pollutants and dangerous gases reduces direct and indirect adverse consequences of air pollution on ecosystems, climate change and society. The provision of clean and fresh air is essential to reach environmental sustainability and sustainable development.

Filters for gases

HS 842139 Filtering or purifying machinery and apparatus: for gases

There are various products under HS heading 842139 such as air filters, smoke extractors and gas cleaners. Most of these products are designed for industrial purposes to purify the air and reduce the amount of hazardous gases. Massive air pollution in large and industrial cities, in both developed and developing countries, has also increased the use of household air filters and purifiers to boost indoor air quality and human health. According to the World Health Organization (WHO), seven million people die annually due to air pollution (WHO, 2014b). To address this important issue, the third United Nations Environment Assembly (UNEA) prioritized improving air quality for sustainable development (UNEP, 2017). As a result, it is important to evaluate the impact of air and gas filter and machinery and their relevance in achieving the SDGs. Table 5.12 outlines relevant sustainability aspects.

5.6.1. Environmental aspects of filters for gases

Filtering or purifying machinery and apparatus for gases are useful to improve air quality and reduce air pollution while partly mitigating climate change (SDG 3, SDG 11 and SDG 13, target 13.2). Air control machines reduce the number of particles in the air. Interestingly, particles like sulphate, nitrate and organic carbon particles tend to have a local cooling effect, while black carbon particles have a warming effect (Menon et al, 2002). Additionally, the reduction of many aerosols in the air positively affects human health (SDG targets 3.4 and 3.9), but does not affect climate change as much as the reduction of CO2 does. Carbon catchers and extractors are new types of air and gas control machinery that can reduce air pollution to a great extent. It is also possible to utilize captured carbon to produce clean energies and reduce negative environmental externalities of traditional fossil fuels.

Air pollution can cause damage to plants, animals and aquatic and terrestrial ecosystems (SDG 14 and SDG 15). The availability of air filters as a reliable source of improving air quality helps reduce greenhouse gas emissions and hazardous gases and conserve biodiversity. Persistent toxic air pollutants (those that break down slowly in the environment) are of particular concern in aquatic ecosystems. These pollutants accumulate in sediments and may biomagnify in tissues of animals at the top of the food chain to concentrations many times higher than in the water or air (target 3.9). It is important to reduce the amount of these toxins with the help of extractors and filters. Gas filters play an essential role in preserving the environment and promoting environmental sustainability.

5.6.2. Social aspects of filters for gases

SDG 3 sets targets to ensure health and well-being for all, at every stage of life, by addressing major health priorities. Deteriorating air quality and air pollution is related to chronic morbidity and mortality (target 3.9) and impacts birth outcomes, especially due to traffic related pollution (target 3.6) releasing aerosols into the atmosphere. These aerosols are made of mineral dust, sulfates, sea salt, carbon and other particles (Rumana et al, 2014). Outdoor air pollution contributes as much as 0.6 to 1.4% of the burden of disease in developing regions, and other pollution, such as lead in water, air, and soil, may contribute 0.9% (WHO, 2002). These numbers may look small, but the contribution from most risk factors other than the "top-10" is within the 0.5 to 1.0% range (Ibid.). A study from China shows that wearing a particle-filtering mask (as a simple type of gas filters) decreases the short-term exposure effects on the heart and blood vessels of exposure to urban air pollution (The Conversation, 2018).

Better health conditions support the reduction of inequality in education (SDG 4). Clean air indirectly contributes to SDG 4 since children in polluted areas are more vulnerable and exposure to toxicants negatively affects their growth. As a result, air control machinery that reduces the amount of dangerous gases can increase school enrollment (target 4.1). In addition, many women, especially in deprived areas, are engaged in indecent works and are in exposure of hazardous gases. Air control machinery can help reduce their exposure to pollutants and improve health conditions and quality of life. Better health conditions enable women to be more social and increase their chance to pursue education that is important to empower women and reduce gender inequalities (SDG 5, target 5.1). Another important factor that increases the standard of living in developing countries is accessibility of affordable and clean energy. Fossil fuels and their pollutants are an affordable main source of energy in developing countries. The utilization of air filters and gas control machineries in the fossil fuel industry is therefore essential to provide cleaner and affordable energy for people (target 7.1). Air and gas filters help to reduce negative environmental externalities from the utilization of fossil fuels, can facilitate the path towards zero-emission systems and enhance the quality of the life in developing countries.

5.6.3. Economic aspects of filters for gases

Industry innovation (SDG 9) plays an important role in creating new technologies to capture hazardous gases and purify the air. The world's appetite to adapt new technologies stimulates research and development in air control machineries, which is key for further development and positive economic effects (targets 9.4 and 9.5). The use of air filters motivates responsible consumption and production (SDG 12). According to the OECD (2016b), the market impacts of outdoor air pollution, which include impacts on labour productivity, health expenditures and agricultural crop yields, are projected to lead to global economic costs that will gradually increase to 1% of global GDP by 2060. Air pollution negatively affects the economy by affecting human health. The use of air filters can improve work conditions to positively affect human health and consequently increase labour productivity (SDG 8, target 8.8).

The sustainability assessment of air and gas filtering machinery illustrates the potential for these technologies to contribute to pollution management in developing countries. The retrofit of existing industries and energy producers can at least help to mitigate some of the environmental damage they cause. Additionally, human health can be greatly improved, creating a foundation for better quality of life including gainful employment, education and equality. One must note, however, that the utilization of gas filters and machineries is not effective on its own and must be implemented with a set of proper policies and measures. Table 5.5 outlines the sustainability assessment.

Table 5.5 Sustainability aspects of filters for gases

EST	Filter for gases HS 842139 Filtering or purifying machinery and apparatus: for gases
Product category	Air pollution control (APC)
Description	A means to reduce air pollution
Use	Used to improve air quality by reducing the number of dangerous particles in the air

Image: Geek Zazu 2018 (https://www.flickr.com/photos/152342724@N04/27527661187/)

Evaluation

	Environmental	Social	Economic
+	• Reduces the number of dangerous aerosols from the air • Reduce pollution in marine and territorial ecosystem and increase biodiversity	• Increase the accessibility to affordable energy since these filters help to reduce air pollution due to fossil fuel consumption • Improves school attendance and gender inequality by improving the health conditions.	• Increase productivity by Improving work conditions and employees' health. • Increase R&D to find new and more efficient technologies to increase air quality
-	• Many parts of these filters are not recyclable and can damage the environment	• Lacking capacity	• It is expensive to install gas filters in all industries.
SDGs & targets	13.2 integrate climate measures in national policies 14.1 reduce marine pollution 14.1.a promote research in marine ecosystem 14.2 sustainably manage marine ecosystem 14.3 minimize the impacts of ocean acidification 15.1 preserve the terrestrial ecosystem	3.1 reduce maternal mortality 3.2 reduce childhood mortality 3.4 reduce pre-mature mortality from NCDs 3.9 reduce deaths from pollutants 3.9.1 mortality rate due to household air pollution 4.1 and 4.2 education for all, 4.5 eliminate gender discrepancies in education, 5.1 end discrimination 5.4 recognize value of domestic work 7.1 universal energy access,	8.2 increase economic productivity, 8.5 achieve full employment and decent work 8.8 promote safe work conditions 9.1 develop reliable and sustainable infrastructure 9.4 upgrade and retrofit infrastructure, 9.5 enhance scientific research 11.6 air quality management in cities

disease in developing regions, and other pollution, such as lead in water, air, and soil, may contribute 0.9% (WHO, 2002). These numbers may look small, but the contribution from most risk factors other than the “top-10” is within the 0.5 to 1.0% range (Ibid.). A study from China shows that wearing a particle-filtering mask (as a simple type of gas filters) decreases the short-term exposure effects on the heart and blood vessels of exposure to urban air pollution (The Conversation, 2018).

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5.7. Sustainability assessment of natural fibres

EPPs are characterized by a lower negative impact on the environment compared to other products with the same end-use (UNCTAD, 1995). Such a comparison is based on a life-cycle perspective of environmental impacts from production, use and disposal of the product (Muthu, 2015). These impacts range from greenhouse gas emissions to eutrophication, freshwater eco-toxicity and many more. It is important to underscore that determining one product as environmentally preferable over another is only partly a scientific task, as subjective value judgements are often required to weigh the importance of various environmental impacts against each other. Natural fibres, for instance, have lower greenhouse gas emissions, but higher land and water use compared to synthetic fibres. Nevertheless, identifying EPPs is an important contribution towards increased sustainability.

While identifying EPPs is a difficult task in general, identifying them in an EST trade liberalization context creates some extra challenges. The HS codes used to identify environmental goods do not separate identical goods based on whether they were produced in an environmentally friendly manner or not. For instance, there is no separate HS codes for organic and non-organic cotton, despite the significant difference in environmental impacts of their production methods. It is important to keep in mind that this is a significant limitation, as the choice of production method and not the product type is often the key to determining what products are environmentally preferable.

Hemp and flax

For HS codes, refer to Table 5.8

In this chapter, we analyse hemp and flax fibres as two EPPs that might substitute cotton for textile use. There is a significant difference between these two products and the four other products analysed in this chapter. While the others were selected because of their trade value and clear environmentally beneficial end-use, hemp and flax represent EPPs, and as such they a) can be potentially important export articles for developing countries, and b) are environmentally preferable as compared to another product with the same end-use, in this case cotton. Flax was also selected because of its relatively high trade value compared to other natural fibres, amounting to a total of USD 3.83 billion globally in 2016, whereas hemp was included despite a low trade value of USD 17 million dollars in the same year (see Annex 10 for trade analysis) because of its exceptional environmental performance across many impact categories. As EPPs only have a focus on comparison of environmental sustainability, the social and economic aspects will be less comparative and include some general social and economic pros and cons of hemp and flax.

5.7.1. Environmental aspects of hemp and flax fibres

Growth of cotton crops has severe effects on water resources (SDG 6) based on today's most prevalent practices. SDG target 6.4 calls for increased water consumption efficiency, and the selection of what crops to grow is an important issue relevant in this case. Comparisons of water footprints show that hemp and flax cultivation generally require significantly less water compared to cotton. Mekonnen and Hoekstra's (2011) research estimates that the total water footprint of hemp is 2719 litres/kg, while flax requires 3783 litres/kg. This compares to cotton which requires an estimated 9982 litres/kg.[66] The consequences of such large water footprints can be severe when crops are grown in arid areas with limited precipitation. Irrigation is usually the solution - putting pressure on lakes and groundwater sources. A case in point is the depletion of

Footnotes

66. It should be noted that these numbers compare processed but not spun flax and hemp fibres versus finished cotton textiles. As a small amount of water is required for spinning and finishing textile products, the value presented for cotton is slightly exaggerated compared to hemp and flax.

the Aral Sea, where only 10% of the total lake volume remains compared to the 1960s, with dire consequences for aquatic as well as human life (Micklin, 2007). One of the main contributors to this depletion is irrigation for cotton production, and it has been suggested that a transfer to less water-intensive crops could partially solve this problem.

Water and air pollution from the use of fertilizers and pesticides is another consequence of natural fibre crop cultivation. SDG target 6.3 aims to reduce water pollution. Due to the impact of contaminants on aquatic life, this target is interconnected with SDG 6.6, which aims to restore and protect freshwater ecosystems. While fertilizer use is a serious problem that causes eutrophication and consequent hypoxia in water bodies, pesticide use is perhaps the area where textiles have drawn the most critique. It has been estimated that the cultivation of cotton uses 8-10% of the worlds pesticides while only occupying 2.5% of arable land (Kooistra, 2006). While the industry is improving due to stricter regulations and development of less damaging alternatives, pesticide use still poses serious environmental and human health challenges (Toprak and Anis, 2017).

This chemical use also has severe impacts on ocean and terrestrial life and is thus not only relevant for healthy freshwater ecosystems (SDG target 6.6), but also the biodiversity in oceans (SDG 14) and on land (SDG 15). Because hemp requires little or no pesticides and only modest inputs of fertilizer (Van der Werf, 2004), it can be considered as more environmentally friendly than cotton. While hemp requires fewer pesticides, findings from a 2012 life cycle assessment study also indicate that flax might be less environmentally damaging than cotton. The study demonstrates that flax fabrics cause six times less damage to the environment, measured according to the life cycle assessment end-point indicator of potential disappeared fractions of species (Muthu et al, 2012).

In relation to greenhouse gas emissions, no sources comparing hemp and cotton were found. However, a life cycle assessment study from the UK demonstrated that flax produced nearly half as many greenhouse gas emissions as cotton. This was mainly due to lower impacts in the fibre, yarn and fabric production stages of the life cycle (Thomas et al, 2012). This indicates that flax might be an EPP compared to cotton seen from a climate change mitigation perspective (SDG 13). As a side note, this is a general advantage of natural fibres over synthetic fibres, as synthetics are produced from oil.

5.7.2. Social aspects of hemp and flax fibres

EPPs are, by definition, identified by their comparative environmental advantage over other products. The previous section therefore provided a discussion of how hemp and flax performed compared to cotton across various aspects of environmental relevance. This section will not contain such a comparative EPP focus, but rather evaluate how flax and hemp production can affect social sustainability aspects.

One of the main social challenges of textile fibre cultivation is health issues related to the use of pesticides. SDG target 3.9 is directly connected to this issue, aiming to reduce the amount of deaths and illnesses from hazardous chemical pollution. Global statistics of morbidity and mortality rates from pesticide use are limited, but research estimates indicate that severe pesticide poisoning cases reach six-digit numbers annually (Kesavachandran et al, 2009). The overwhelming majority of these cases occurs in developing countries where health, safety and environment regulations are less strict and the use of illegal hazardous pesticides is a common occurrence (Kooistra, 2006). The people affected are most commonly agricultural workers who are directly exposed, but also citizens who are exposed indirectly through contaminated water bodies. To lower the occurrence of these health problems, sustainable agricultural practices like decreased pesticide use and water treatment are viable solutions. This would also be another reason why hemp and the limited need for pesticides to cultivate it makes it a socially preferable product compared to cotton.

The economic income of rural populations often depends on agriculture. Therefore, increasing growth of hemp and flax might also be an important contribution to address

SDG 1 - poverty (Muthu, 2014). Furthermore, flax fibre production also creates by-products like flax seeds, which contain omega-3 rich oils, and contribute to a healthy diet (SDG 2 and 3). The same oil could also potentially be used for biodiesel production - a clean energy alternative for petroleum products and relevant for SDG 7 of clean energy production. In Turkey, it is estimated that the current oil seed crop production of 1.2 million tons could potentially be ten times higher if all usable land was cultivated (Eryilmaz, 2016).

5.7.3. Economic aspects of hemp and flax fibres

As mentioned, the inclusion of EPPs as an EST category is based on their economic potential for developing countries, which highlights its relevance for decent work and reduced inequalities formulated in SDG 8 and SDG 10. While most developing countries are net importers of goods like solar panels and water filters, they are net exporters of many EPPs. Flax is one of the best examples of this. As we have seen from the trade analysis, natural fibres represent significant export value for many developing countries, with a total trade value of almost USD 7 billion in 2016, with flax contributing almost 60% of this total. Increased production and trade in these products is therefore likely to contribute to SDG target 10 of reduced inequality within and between countries. This necessitates that most of the value creation and capture in the supply chain occurs in developing countries, and that it is complemented by increasing trade of high technology goods as well. Relying on the sale of raw materials will not be enough to reduce the economic challenges of developing countries.

Finally, hemp and flax production also appear to be good candidates for sustainable consumption and production (SDG 12). Their reduced pesticide requirements create less chemical waste than cotton, which is specifically addressed by target 12.4. They are also closely connected to the more general target 12.2 of sustainable management and efficient use of natural resources. Another benefit of hemp and flax is that they are useful in crop rotation systems, where multiple types of crops can be grown on the same area at different times of the year. Such rotation enriches the soil and reduces the occurrence of pests, and therefore the use of pesticides (Blackburn, 2009). Furthermore, other parts of the plants can be used for plant oil production, and ongoing research points out more alternative applications, such as the use of natural fibre composites to replace concrete in buildings (Azwa, 2013) and even applications in the aerospace industry (Puttegowda et al, 2018). With such technological development broadening the potential areas of application for natural fibres, the future demand for them may increase.

This analysis has provided a case for hemp and flax fibres as EPPs compared to cotton. The overview of the sustainability assessment is presented in Table 5.6. Due to their potential importance for developing country economies, they represent an important part of EST trade. The position of hemp, flax and other EPPs could be strengthened, not only by trade liberalization, but also other sustainability policies, regulations and increasing consumer awareness. However, it is important to stress once again that production methods can be equally or even more important to address from an environmental sustainability perspective. The potential of flax and hemp products as substitutes for cotton are admittedly limited, due to differing mechanical properties and higher production cost. It is therefore important to consider strategies for incorporating environmentally preferable production methods as part of EPP trade liberalization, and enabling separation of products with the same physical properties, but with different environmental performance. In the case of cotton for example, one way to do this would be to explore the possibility of creating an ex-out for organic cotton within the HS code system.

Table 5.6 Sustainability aspects of natural fibres

EST	Hemp and flax fibres HS 530121, 530919, 530610, 530929, 530911, 530129, 530620, 530110 and 530210, 530820
Product category	Environmentally preferable products (EPPs)
Description	Includes hemp and flax products traded at various stages of the production process: raw, retted, spun etc.
Use	Environmentally preferable alternative to cotton textiles

Evaluation

	Environmental	Social	Economic
+	• Lower water footprints and pollution of water bodies by pesticides and fertilizers • Less damage to oceanic and terrestrial biodiversity • Lower GHG emissions	• Potential income source for rural populations in developing countries • Flax and hemp seeds can be used as a healthy food source • Reduction in health problems related to pesticide poisoning • Oil from flax and hemp seeds can be used for biodiesel	• Large export potential for developing countries • Labour intensive industry, providing jobs in rural areas • Flax and hemp can be used in crop rotation system
-		• Hemp processing causes unhealthy dust pollution	• It is expensive to install good and efficient waste incineration plants in developing countries
SDGs & targets	6.1 Water access 6.3Water pollution reduction and increased wastewater treatment 6.4 Water-use efficiency 14.1 Reduce marine pollution, including nutrient pollution	2.1 Nutritious food 2.4 Sustainable food production 3.9 Reduction of deaths and illnesses from air, water and soil pollution 7.2 Increase share of renewable energy sources	8.1 Sustain per capita GDP growth 8.5 Achieve full employment and decent work 10.1 Sustain income growth of the bottom 40 per cent of the population 12.2 Sustainable use of natural resources

5.8. Relations to other sustainability assessment frameworks

The framework for the sustainability assessment presented in this chapter outlines an approach to follow for an overview of sustainability aspects and SDG contributions related to a specific EST. Other methodologies have also been developed to evaluate the sustainability impact of international trade agreements in environmental goods (EC, 2016b) or to assess a specific technology for intervention in solving a problem (UNEP, 2012b).

The Trade Sustainability Impact Assessment (Trade SIA) on the EGA was released by the European Commission (2016b) to analyse the impacts of trade liberalization associated with the WTO EGA. The Trade SIA undertakes a quantitative and qualitative assessment of the impact of trade liberalization on environmental and socio-economic factors. It also includes a consultation of stakeholders to incorporate the needs and opinions of a broad international group. Environmental goods are analysed across 10 EGA product categories for their potential to reduce environmental impacts and aid climate change mitigation, in order to incorporate the effects of greater regulation and multilateral environmental and trade agreements, to predict the impact on trade in environmental goods, and to understand the potential social improvements in areas such as human rights and decent work. The report concludes that the EGA would have positive impacts on many environmental and socio-economic aspects, on trade in environmental goods, and on achieving the SDGs (especially goals 6 and 7). The Trade SIA provides a comprehensive analysis of the trade potential for the EGA and its resulting effects on environmental and social factors. While it looks at a specific WTO agreement and informs the multilateral context, our assessment instead maps the sustainability contributions of a specific EST.

Another sustainability assessment methodology related to ESTs is UN Environment's (2012b) 'Sustainability Assessment of Technology (SAT) Methodology.' It was developed for assessing different technologies for intervention in problems related to e.g. basic infrastructure development, land remediation, waste and water management and biodiversity management. Based on a set of criteria related to the intervention context, the SAT Methodology provides a framework for qualitative and quantitative assessment. Through 'screening', 'scoping' and 'detailed assessment' steps, it helps to identify the best technology to solve the problem at hand. Additionally, the inclusion of stakeholder consultation, quantitative impact analysis and continuous improvement principles make the SAT methodology a comprehensive approach for the consideration of specific contextual factors. The SAT Method differs from the approach in this report due to its objective. It works to find the best technical solution to a specific problem, while our framework outlines the sustainable development contributions and limitations of an individual EST.

The Trade SIA (EC, 2016b), SAT Methodology (UNEP, 2012b) and the assessment in this report provide analytical frameworks for different types of assessment of ESTs. All have a different approach and objective. There are many complementary aspects related to meeting sustainability principles, but they cannot be directly compared as they are designed to produce different results. While the Trade SIA appraises the potential impacts of the EGA on global trade and environmental and social aspects, the SAT method helps to find the best technical solution to a specific development problem.

To provide a more comprehensive assessment of the multidimensional aspects of specific ESTs, the framework in this chapter could be extended to incorporate some of the steps used in the other methods. As mentioned earlier, quantitative impact assessment was outside the scope of this study, but could strengthen the framework's objectivity and allow for more comparability between ESTs. A combination of the three methods provides an interesting avenue for further research that allows for comparable assessments of technologies for different contexts and incorporates such impacts on global trade.

5.9. Discussion of sustainability assessment

Finally, the sustainability assessment has shown that using the economic lens as the starting point of analysis may provide an oversimplified view of the sustainability impact. Similarly, looking primarily at the environmental and social impacts does not provide the full picture of the enabling policies of trade initiatives and agreements. The implications of ESTs must therefore be discussed across varying levels of impact. These levels span multiple factors, including the level of implementation (from micro to industrial), the level of technical sophistication and economic value (from sustainable natural fibers to solar PV cells), the impact on environmental sustainability (from climate change to local ecosystems), and the impact on social sustainability (from meeting basic needs to providing environmentally preferable luxury goods). They also require focused attention on the development and integration of phase-in policies and capacity building services adapted to local contexts. As asserted in this chapter, environmental services are essential to the positive implementation of environmental goods, and can help to meet some of the challenges described in this chapter. The results of the analysis also underline the need to address barriers at all stages of the value chain, including different components, intermediate products, goods and services.

6. Implications for trade governance

Regional and plurilateral trade initiatives as stepping stones towards multilateral trade initiatives

A clear shift in engagement of countries - both developed and developing – away from multilateral trade negotiations towards plurilateral and regional initiatives can be observed. RTAs are often criticized for not leading to the most optimal outcome for trade (and possibly also for environmental protection) given the danger of diverting trade (including in ESTs) away from the most efficient producers. However, participation in RTAs could provide countries, especially developing ones and LDCs, with access to bigger markets and gradually increase competitive exposure for their domestic industries before venturing into bigger plurilateral agreements such as the EGA. RTAs could also provide useful templates for testing technical co-operation and capacity building measures, which, if successful, could be replicated in bigger plurilateral agreements such as the EGA or at the multilateral level. Given the growing dynamism of South-South trade, South-South RTAs could also provide a good opportunity for developing countries to access ESTs based on their domestic environmental priorities, from countries where local conditions and technology needs may be similar as well as tap into opportunities for potential export markets in these countries. Moreover, those regional and plurilateral trade initiatives can serve as stepping stones towards multilateral trade initiatives, particularly for middle-income developing countries and LDCs.

The engagement on environment and ESTs is clearly picking up within RTAs. This is particularly the case for environmental services, even as many environmental goods have been liberalized within the context of comprehensive RTAs covering all or most goods and services. Standalone environmental goods RTAs are only three so far - the New Zealand-Chinese Taipei FTA, the ALADI agreement between Argentina, Brazil and Uruguay and the Vladivostok APEC Agreement - of which the APEC Agreement is purely voluntary and the other two are part of broader regional frameworks liberalizing a broader range of goods and services.

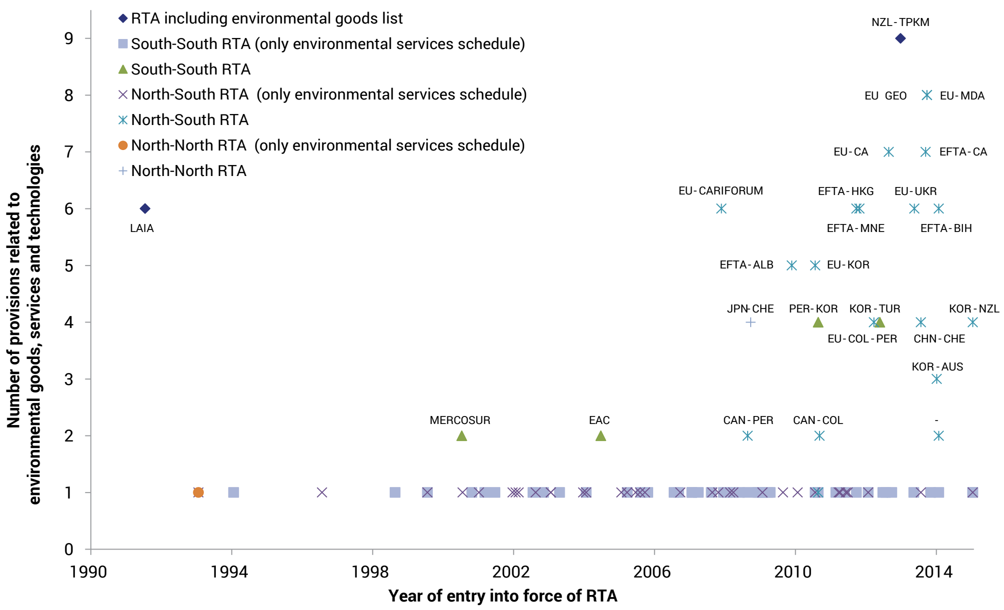
Figure 6.1 below reveals a pattern in the evolution of RTA provisions related to environmental goods and services. Such RTAs show a rapid increase after 2006 and particularly after 2010, which could be related to the slowdown and eventual stalling of environmental goods and service negotiations under the Doha Round. While most RTAs referring to environmental goods include EGA members (particularly EU and

Footnotes

67. Iceland, Liechtenstein, Norway and Switzerland. (EFTA, n.d.)

EFTA countries,[67] the Republic of Korea, Canada, China and the US), they also include a number of non-EGA members such as Albania, Bosnia, Colombia, Georgia, CARIFORUM countries,[68] the East African Community (EAC),[69] India, the Mercosur and ALADI countries comprising Argentina, Brazil, Paraguay and, Uruguay as well as Moldova, Peru and the Ukraine. The EAC, Peru- Republic of Korea and Republic of Korea-Turkey are also interesting examples of South-South RTAs that refer to environmental goods especially involving Peru, China, Malaysia, Republic of Korea and Mexico. (See Annex 2 for full list of RTAs.) At the same time, despite the lack of concrete outcomes, multilateral and plurilateral negotiations have also seen a high degree of engagement and exchange of views among parties on environmental goods and services which will likely facilitate further engagement in the regional context as well.

Figure 6.1 Evolution of RTA provisions related to environmental goods and services[70]



Depending on the extent and ambition of parties to RTAs, there may be an increase or decrease in the number of future standalone agreements on environmental goods. If the depth and pace of liberalization of an RTA is very ambitious, parties may feel less of a need to prioritize a subset of environmental goods for faster liberalization. But in RTAs where the pace of liberalization is more gradual and a number of products are excluded for being sensitive, countries may wish to consider a separate chapter on environmental goods as well as priority liberalization of selected ESTs - both goods and services - as a sign of commitment towards meeting global and national environmental objectives.

Footnotes

68. Comprising Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, Saint Kitts and Nevis, Suriname, and Trinidad and Tobago. Haiti and Cuba, which are part of the CARIFORUM confederation, too, did not sign this agreement. (ESF, n.d.)

69. The Republics of Burundi, Kenya, Rwanda, South Sudan, the United Republic of Tanzania, and the Republic of Uganda (EAC, n.d.).

70. Source: Computations based on WTO RTA Database from Monteiro (2016).

Environmental chapters as well as various provisions on environmental protection including provisions not to lower or relax environmental laws (such as found in the CETA between the EU and Canada or the Panama-Chinese Taipei FTA), as well as pledges to improve environmental performance levels over time, could provide a useful template for inclusion in future RTAs even if they may be aspirational. Such norms can provide a useful reference point and help complement and support the introduction of new domestic environmental laws and regulations and encourage effective enforcement. This in turn can help in the creation of new markets for ESTs and serve as a demand driver for both domestic as well imported ESTs. A conducive environmental regulatory framework, as has been pointed out by many experts and referred to earlier in the review of literature and findings on ESTs in this report, is essential for market development and can enable trade-related initiatives addressing barriers to ESTs to have a more meaningful impact. Such provisions could therefore be replicated and strengthened in future RTAs while providing adequate flexibility as well as appropriate regulatory 'space' for implementing countries in tune with their local needs and conditions.

It must be borne in mind that most RTA negotiations are not focused exclusively on ESTs and may have an ambitious liberalization agenda involving most or at least a very large number of goods (agricultural and industrial) as well as services. In such cases, debates on narrowly limiting liberalization to environmental end-use goods may not be relevant as all or most goods and services will be liberalized anyway in a specific time-frame and this liberalization will automatically cover most or all ESTs and their parts (unless specifically exempted by one or more of the parties to an RTA). What may be important in such cases is to ensure that products deemed environmentally harmful relative to their environmentally friendlier counterparts do not enjoy an unfair tariff or trade advantage. An example of such negative impact would be if an RTA eliminates all tariffs on diesel powered generating sets while maintaining higher tariffs or imposing anti-dumping duties and safeguards on solar PV modules and lithium-ion batteries that could be used by households to substitute diesel generators.

Irrespective of the level the negotiations are taking place at, the report finds some factors that would contribute to more beneficial and inclusive EST trade governance.

Taking an integrated approach to environmental goods and services negotiations

ESTs include both environmental goods as well as environmental services and they are often deployed in a joint manner to perform an environmental function. Liberalization of environmental services markets while imposing trade barriers on environmental goods and vice versa may not result in cost-effective deployment of ESTs to address major environmental challenges such as air and water-pollution. Yet, as far as trade agreements are concerned and despite Paragraoh 31 (iii) of the WTO's Doha Ministerial Declaration that refers to "the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services" in a single mandate, there has not yet been an integrated approach to liberalizing both jointly. This may also have to do with the different nature of barriers affecting trade in services, the different modes of their delivery and also the much closer relationship of services trade with foreign direct investment (in the case of mode 3). Negotiations on environmental services have always been conducted separately, whether during the WTO Doha Round (within the Council on Trade in Services) or in plurilateral negotiations (negotiated with other services as part of TiSA rather than under the EGA). The APEC negotiations also addressed environmental goods, but not services. At the same time, there are many more RTAs with commitments on environmental services as opposed to only two that have stand-alone commitments on environmental goods. Despite this disconnect, trade negotiators can enable better coordination by ensuring for example that goods that are important or critical for the delivery of environmental services are also included in market access negotiations on goods.

Addressing nuisance-tariffs and non-tariff barriers

A review of tariffs for selected environmental goods related to ESTs (with a clearer environmental end-use), spare parts (used in hydraulic and wind turbines) and three EPPs for some of the top traders among developed and developing countries as well as LDCs reveal very low or even zero tariffs for many of these products among both developed countries such as Germany, Japan and the US and for LDCs such as Tanzania and Mozambique (see Annex 11). Countries with the highest MFN (applying to all non-preferential trading partners) and bound (ceiling) tariffs appear to be the bigger emerging market developing countries such as Brazil, India, China and South Africa. These are in the mid to high single digits for EPPs as well in China, Brazil and India. Lowering tariffs on EPPs by the larger developing countries could thus represent an interesting export opportunity for LDCs producing these EPPs to export to these large and growing markets.

Amongst the larger developing countries, only China, which is also amongst the top traders of EST-related environmental goods, has been engaged in the plurilateral EGA negotiations, while only Mexico has been engaging in the TiSA. Greater engagement in EST trade negotiations and commitments in EST sectors by China could offer greater predictability for foreign investors and drive investment flows into EST sectors in China. This will help address growing environmental challenges such as air-pollution and waste management. It could in turn also help domestic Chinese EST firms that are already competitive in the world market to supply to foreign EST firms operating within their territory. Among the three developed countries, Japan appears to have the most liberal trade regime with bound, applied and MFN duty-free access for all products considered. The US and Germany also appear to have duty-free access to the EPPs considered, which may be representative for similar EPPs and represents useful opportunities for LDCs and other developing countries looking to export such products.

While tariffs for many ESTs appear to be very low (single digits) in developed country markets such as the US and Germany, a case could be made for eliminating even these very low tariffs (so-called 'nuisance' tariffs) as they would help reduce administrative costs for customs authorities and thereby facilitate smoother entry of ESTs into these markets. Such an outcome (outside of RTAs) may no doubt have to await the successful conclusion of the EGA in which the US, EU and China are major participants.

Finally tariffs themselves, given that they are very low or zero for many environmental goods in major developed country markets and LDCs, may not represent the main barriers to EST trade. Rather non-tariff measures such as standards and certification as well as related accreditation requirements and customs related impediments at the border could represent greater barriers, both for traditional environmental goods as well as EPP exports for both North-South as well as South-South trade. For instance, the WTO's Environmental Database reports 1176 notifications on environmental measures made by WTO Members (US, Australia and the EU together account for 27% of all notifications) in 2016, of which the majority relate to technical regulations or specifications (29.2%), followed by grants and direct payments (13.7%) and non-monetary support (11.3%) (see Table 6.1). Such measures, if they constitute trade barriers, need to be tackled at all stages of the global EST value chains, including components, intermediate products and different aspects like goods and services.

Balancing import sensitivities with environmental impact and value chain and investment related benefits

To promote negotiations and participation while ensuring environmental credibility, a balance needs to be found between the elements of easy identification and justification from an environmental perspective, ease of identification as an environmental good at the customs level (particularly in the case of EPPs), criticality of application in an environmental end-use project, as well as sensitivities of countries with regard to imports whereby they may wish to have a longer or more phased reduction in tariffs or exemption from tariff reduction for certain products.

Table 6.1: Top environmental-related measures imposed by WTO members in 2016

Type of measure	Count of measure	Share (%)
Technical regulation or specifications	343	29.2
Grants and direct payments	161	13.7
Non-monetary support	133	11.3
Import licences	96	8.2
Ban/Prohibition	74	6.3
Countervailing measure / investigation	59	5.0
Conformity assessment procedures; Technical regulation or specifications	52	4.4
Not specified	43	3.7
Grants and direct payments; Non-monetary support	23	2.0
Conformity assessment procedures	22	1.9
Export licences; Import licences	17	1.4
Export licences	16	1.4
Loans and financing	10	0.9

Source: WTO's Environmental Database; authors' compilation

To secure greater engagement of developing countries and LDCs in initiatives like the EGA, some degree of flexibility for any sensitive products (for instance through longer phase-out periods) may be required. At the same time, such sensitivities may need to be weighed against any immediate environmental benefits that market opening in 'sensitive' sectors may bring as well as other benefits further down the value chain, as for example in terms of job creation in the downstream services sectors. This is brought out in the example of the adverse downstream job impacts of anti-dumping and safeguard duties on jobs in solar PV modules installation highlighted earlier in the report.

Also, from a value chain perspective, low duties for spare-parts could help domestic industries that use such parts in manufacturing of finished equipment. Counter-intuitively, Brazil and South Africa apply higher average MFN duties on spare parts for wind turbine generating sets while applying zero duties on finished wind-powered generating sets. This may not be helpful for their domestic wind-powered generating set manufacturers that would wish to scale up production and require access to competitively priced components. Given the complex local and regional contexts each country is facing, it is important though to keep in mind that there is no one-size-fits-all solution and country-specific factors need to be taken into consideration when assessing different policy options.

Identifying EST sectors of promising opportunity for developing countries

Additionally to taking potential product sensitivities into account, trade negotiators may consider including products of export interest to developing countries and LDCs that engage in trade negotiations. While developing country shares of trade in ESTs outside of a handful of upper and middle-income developing are still low, products that feature amongst the top exports could be considered for inclusion. For example, the trade analysis in this report shows that over the period 2006 - 2016, parts for electricity generators (HS 850300) is a product ranking at the top amongst exports of EST-related environmental goods for LDCs such as Ethiopia, Tanzania and Mozambique (see Annex 3). Similarly, towers and masts including those used for wind (HS 730820) rank among the top exports of EST-related goods for Ethiopia and Tanzania. While not all of these spare parts exported may be intended for clean energy, the fact that they may have such end-uses and the fact they are also among top exports of LDCs could be a strong argument to qualify them for inclusion.

The environmental, social and economic benefits as well as opportunities and challenges associated with liberalizing EPPs have been highlighted in Chapters 4 and 5 of this report. Chapter 5 also links EPPs such as natural fibres to the realization of several important SDGs. The trade analysis in this report shows that even among selected EPPs, developed countries such as the US and European countries as well as higher and middle-income countries such as China, the Republic of Korea and other BRIC countries tend to dominate exports and imports. For the period 2006 - 2016, it appears that EPPs figured prominently in LDC exports. For instance, jute and textile bast fibres were amongst the top EST exports of Tanzania and Mozambique (see Annex 3).

A similar pattern of participation in trade flows, with developed countries and China dominating, also appears in the case of environmental goods related to ESTs with a clearer environmental end-use such as solar PV modules, filtering or purifying apparatus for gases. However, an interesting observation is that a greater diversity of developing countries appears among the top ten developing country exporters and importers of these ESTs with a clearer environmental end-use. These include countries such as South Africa, India and Brazil that have not participated in initiatives such as the EGA or APEC negotiations on environmental goods, even though they appear as the fourth, fifth and sixth largest exporters in this category among developing countries. These are countries to watch out for in terms of future trade participation for such goods. Moreover, India appears as the third-largest importer while Brazil is the eighth largest importer for environmental goods with clear environmental end-use. Non-participation in the EGA and similar trade initiatives therefore risks making it more of a challenge for EST traders (including other developing countries= to access these markets, given their higher average of applied MFN tariff rates for many ESTs (see Annex 11).

Finally, certain examples of ESTs that can clearly be identified as environmental goods even at the HS-6-digit level also appear amongst the top exports of LDCs, including wind-powered generating sets, filtering and purifying machinery for gases, liquids and water, even if the associated trade values are relatively small. These products are encouraging as candidates for inclusion in all future trade agreements as they can also be clearly linked to environmental impacts such as remediation of air and water pollution. They are furthermore relevant for delivery of services to remedy air and water pollution as the previous sections show.

The potential from tariff and non-tariff liberalization of ESTs for developing countries is also borne out from the analysis in Table 6.2 that reports the revealed comparative advantage (RCA) index for top three exporters of ESTs with clear environmental end-use across developed, developing and LDC groups over 2006 - 2016. China, Mexico and Malaysia have much higher RCA values compared to Germany, USA and Japan in 2011 and 2016 (even though the position was reversed in 2006), suggesting a potential competitive advantage in exporting certain ESTs. In fact, the US has ceased to report an RCA in exporting ESTs since 2011, while the LDCs reported in the table (Ethiopia, Mozambique and Tanzania) never exhibited one during this time period.

Table 6.2: RCA Index for the top-3 exporters of ESTs with clear environmental end-use across countries

	2006	2011	2016
Developed			
Germany	1.92	2.01	1.74
USA	1.21	0.81	0.78
Japan	2.62	1.84	1.49
Developing			
China	1.09	2.89	2.19
Mexico	1.31	1.34	1.59
Malaysia	1.55	1.96	4.38
LDCs			
Ethiopia	0.00	0.05	0.05
Tanzania	0.00	0.01	0.02
Mozambique	0.02	0.00	0.03

Note: Revealed Comparative Advantage is calculated by:

$$RCA_{cp} = \frac{E_{cp} / \sum_{p' \in P} E_{cp'}}{\sum_{c' \in C} E_{c'p} / \sum_{c' \in C, p' \in P} E_{c'p'}}$$

where E stands for exports, c and c' stand for country index, C stands for set of countries, p and p' stand for commodity index, P stands for set of commodities

Source: Authors' calculations based on Comtrade and World Bank data.

A more detailed RCA analysis of the top ten ESTs with clear environmental end-use in Chapter 3 and Annex 4 further reveals that among developed countries the Republic of Korea, Japan and Singapore and among developing countries China and Viet Nam appear to gain comparative advantage for more ESTs in 2016 as compared to 2006. Among LDCs, only New Caledonia, Niger and Senegal appear to show an RCA for at least one EST with a clear environmental end-use. Wind towers and lattice masts (HS 730820) and solar PV wafers, cells and modules/LEDs (HS 854140) appear to be two product categories where a greater number of developing countries seem to show an RCA in exporting. Among the three above-mentioned LDCs, it is interesting that products such as solar water-heaters (included in HS 841919), water purification equipment (HS 842121) and parts for electricity generators (HS 850300) appear as products of export interest despite the overall low RCAs among LDCs in general. Most of these are lower technology products which are usually easier for LDCs to enter into from a manufacturing perspective. Addressing tariff and non-tariff barriers in these products in potential export markets may therefore benefit these LDCs.

The intra-industry trade (IIT) analysis in Chapter 3 and Annex 5 also shows a significant prevalence of value-chain-type trade with the rest of the world among developed countries in most of the identified top ten traded ESTs with clear environmental end-use, as is also the case for developing countries (particularly for non-participants in the EGA such as India, Mexico, Thailand and Turkey, which show a jump in scores for 2016). Four of the top ten EST-related goods show a greater prevalence of value-chain-type trade with rest of the world for developing countries and therefore particularly likely benefit from greater global and value chain integration arising from EST liberalization. These include water purification equipment (HS 842121), filtering or purifying machinery and apparatus for gases (842139), parts for electricity generators (850300) and not surprisingly solar PV wafers, cells and modules/LEDs (HS 854140). Interestingly, these products are also reflective of three major EST categories relevant to important SDGs (air-pollution control, water and wastewater treatment and renewable energy). For LDCs however, the degree of value chain integration is shown to be relatively weak except in the case of solar water heaters (HS 841919) for Benin and Mozambique, hinting at greater potential for integrating these countries into regional and global value chains for solar water heaters.

However, it may be difficult to draw definite causal inferences or conclusions for trade governance or green industrial policy, particularly from the RCA analyses as both the factors driving RCA scores and the impact of scores on growth and development are unknown. In addition, because of the segmentation of many products along global value chains, the RCA is not calculated based on value-added data and can hence be misleading.

Continuing engagement at the multilateral level: Addressing non-tariff issues affecting ESTs trade and green industrial policy in various relevant WTO Committees

While the Doha Round negotiations on lowering tariffs and non-tariff barriers may be stalled and the focus of negotiations on ESTs appears to have shifted towards plurilateral and regional agreements, the WTO remains the only multilateral trade institution with binding rules and an effective dispute settlement system that bring the majority of countries — developed as well as developing — under a single set of trade-related rules and obligations.

Trade policy makers should therefore pursue options to address various issues relevant to addressing non-tariff barriers as well as green industrial policy in ESTs within the context of other areas of the negotiating mandate as part of a revived Doha process as well as outside the Doha mandate. This could include, for example, utilizing ongoing regular work in various WTO Committees as well as 'built-in' mandates for negotiations such as provided under Article XV and Article XIX of the GATS. A few specific options for continued engagement at the multilateral level are discussed below:

i) Effective development and clarification of trade rules through other existing provisions of the Doha mandate

Trade remedy measures will take on increasing significance as tariff barriers on ESTs are lowered or removed. Under Paragraph 28 of the Doha Declaration, WTO members have agreed to negotiations aimed at clarifying and improving disciplines under the Anti-dumping Agreement and the Agreement on Subsidies and Countervailing Measures, while "...preserving the basic concepts, principles and effectiveness of these Agreements and their instruments and objectives, and taking into account the needs of developing and least-developed participants." As EST import tariffs have been lowered or eliminated particularly on solar PV cells and modules (including on HS 854140 subheading under the Information Technology Agreement), a surge has been witnessed in the use of anti-dumping duties and countervailing measures on solar PV cells and panels. Some experts have called for a moratorium on such trade-remedy measures in the interests of climate change mitigation. While this may perhaps not be feasible in the short to medium term, better clarification and development of rules under these agreements and using the window provided by Paragraph 28 could open up possibilities for WTO members to arrive at solutions that preserve fair competition while avoiding frequent use of trade remedy measures that increase costs for clean energy developers. WTO negotiators may also wish to examine disciplines on environmentally unfriendly 'brown' economy sectors that would eventually lead to reform or removal of such subsidies and enable a more level playing field for EST sectors such as clean energy.

Similarly, GATS rules already provide (under Article XV) for multilateral disciplines for subsidies on services (WTO, n.d.-d). WTO members may wish to examine the types of subsidies relevant for EST-related service sectors and develop appropriate disciplines that ensure that subsidies cause minimal trade distortion while also enabling space for the legitimate use of subsidies required for green industrial policy in environmental service sectors.[71] Moreover, disciplines on domestic regulation and technical requirements for entry of services providers could be further clarified under the GATS.

In addition to negotiations, the Doha Declaration also provides an opportunity to promote clarity on issues and rules relevant to trade in ESTs in a non-negotiating framework. One example is the mandate of the ongoing work programme under Paragraph 32 of the Doha Declaration. Paragraph 32 states that work in the regular session of the WTO's Committee on Trade and Environment should include the identification of any need to clarify WTO rules including those on relevant provisions of the Agreement on Trade-Related Aspects of Intellectual Property Rights and labelling requirements for environmental purposes. Another example is Paragraph 37 on the Transfer of Technology, which calls for examination within a working group of the relationship between trade and transfer of technology, and of any possible recommendations on steps that might be taken within the mandate of the WTO to increase flows of technology to developing countries. Such a working group could also examine special EST-related needs of developing countries and LDCs.

The above proposals of course do not discount in any way the challenges that could be faced in eventual multilateral negotiations on these issues. Detailed and extensive proposals for changes to the Anti-dumping Agreement, in particular, were tabled between 2001 and 2011 and did not lead to consensus (Kampel, 2017). However, despite such setbacks there is no alternative than to continue discussions and explore creative solutions for rules reform.

ii) Using flexibilities under the Government Procurement Agreement to promote sustainable procurement

Sustainable public procurement can play a very important role in the transition towards a green economy as its share in GDP accounts for between 12% (in OECD countries) and 30% (in many developing countries). It can also be a tool to drive both EST-related standard-setting as well as a tool of green industrial policy (PAGE, 2017). The revised plurilateral Government Procurement Agreement (GPA), while maintaining (under Article IV) rules on non-discriminatory procurement of covered goods, services and construction services, also provides some flexibility for the pursuit of social and environmental objectives under Articles X (6) and (9).[72] Article III (2) also allows exceptions to allow discriminatory measures necessary to protect human, animal or plant life or health.[73] WTO members may wish to further explore ways of using flexibilities under the GPA to enable sustainable procurement as an engine to drive the growth of EST sectors. Similarly, they may also wish to take note of provisions on government procurement in various RTAs, including provisions on eco-labelling, production cycles, as well as a variety of references to renewable energy and energy efficiency, as a template for eventual multilateral provisions.[74] Further, under Article V, the revised GPA also provides special

Footnotes

71. A detailed typology of such subsidies including those related to trade are described in PAGE (2017)

72. Articles X (6) allows parties to prepare, adopt or apply technical specifications to promote the conservation of natural resources or protect the environment. Article X (9) allows the evaluation criteria set out in the notice of intended procurement or tender documentation to include environmental characteristics and terms of delivery.

73. Revised Agreement on Government Procurement (WTO, n.d.-e).

74. For e.g. Articles 19.9(6) and 19.9(9) of the EU-Canada Comprehensive Economic Trade Agreement (CETA) which are similar to Articles X (6) and (9) of the GPA (PAGE, 2017).

and differential treatment (S&DT) related exceptions for least-developed and developing countries such as preferences for domestic suppliers for part of the tender. Notably, non-parties to the GPA have much more leeway with regard to industrial policy measures. For instance, using the flexibility under Article III 8 (a), they may be able to specify local content measures relevant to goods and services purchased for governmental consumption (such as off-grid solar panels purchased for government buildings or defense installations) even though there may be restrictions under the Agreement on Trade Related Investment Measures or the Agreement on Subsidies and Countervailing Measures on maintaining local content measures and related incentives for projects where goods and services would be sold on a commercial basis (for e.g. solar panels used on grid-connected clean energy produced for sale to utilities). Such local-content should however meet specific conditions such as being competitive in terms of price, quality and timely availability. Procurement related policies to promote domestic green manufacturing should be designed keeping in mind several considerations based on best practices worldwide in addition to consistency with WTO obligations (UNCTAD, 2014).

iii) Encouraging clarity on standards-related rules and facilitating mutual recognition agreements

Standards and accreditation procedures, while often designed with legitimate objectives in mind such as quality, safety and performance, can also be a non-tariff barrier to trade if they are designed in a manner that is arbitrary or imposes high compliance costs. This applies to ESTs as well as to other sectors. Standards and labelling measures may be particularly relevant to facilitate the comparison among various types of EPPs. While standards are set in relevant standard-setting forums, the WTO Agreement on Technical Barriers to Trade lays down disciplines that regulate the use of standards in international trade so as to enable countries to meet legitimate objectives while avoiding protectionist misuse. Article 2.2 of the Agreement requires that "technical regulations are not prepared, adopted or applied with a view to, or with the effect of, creating unnecessary obstacles to international trade." Article 2.4 obliges WTO members to use relevant international standards if they exist as the basis for technical regulations and Article 5.4 similarly obligates it for conformity assessment measures except where it becomes ineffective or inappropriate.[75] However, there still exists further scope within the Agreement to clarify the treatment of 'private standards' and standardization activity by local governments and nongovernmental bodies. Other gaps include the need for more effective disciplines on certification requirements and accreditation procedures (Sugathan, 2013b). Streamlining the notification process for the standards of the Agreement and a system to better identify and link standards notifications to ESTs at the HS-6 digit level or 'ex-out' level under the WTO's Technical Barriers to Trade Information Management System could also be explored (WTO, n.d.-g, n.d.-h). Innovative and useful tools such as the E-ping notification alert system for notifications under the Agreement of Technical Barriers to Trade and the Agreement on the Application of Sanitary and Phytosanitary Measures developed by the WTO, the United Nations Department of Economic and Social Affairs (UNDESA) and International Trade Centre (ITC) could also be further tailored to the needs of EST exporters (ePing, n.d.). Finally, Article 6.3 of the Agreement on Technical Barriers to Trade also encourages mutual recognition agreements for conformity assessment procedures. A large number of bilateral mutual recognition agreements exist, including within RTAs. There are also RTA provisions for automatic acceptance of declarations for conformity and test reports, such as for instance under Article 7.5 (3) of the EU-Singapore FTA, where solar panels and wind-powered electric generating sets are specifically highlighted. Otherwise, no standalone mutual recognition agreements exists for ESTs. One possibility may be to explore specific mutual recognition agreements for ESTs either within or outside the WTO where this may greatly help to facilitate trade.[76]

Footnotes

75. Agreement on Technical Barriers to Trade (WTO, n.d. -f).
76. See for instance Sugathan, 2016.

7. Conclusion

World trade in ESTs has generally been on an upward trend, increasing by almost 60% from USD 0.9 trillion in 2006 to USD 1.4 trillion in 2016, with a peak of roughly USD 1.6 trillion in 2014.

During the period 2006 to 2016, developing countries' share in world trade in EST-related goods has been growing. While developed countries continue to dominate trade in ESTs, their share of total trade has started to decline from its peak in 2011. Developing countries, other than BRIC countries, have managed to increase their share of exports although they continue to be net importers. Asia is home to some of the most active developing countries in EST trade, namely China, the Republic of Korea and to a smaller extent Malaysia, Philippines and Thailand. Indeed, China features among the top ten global traders in terms of both exports and imports of EST-related goods. Mexico and to a lesser extent, Brazil are dominant players in Latin America.

This clearly highlights the growing importance of developing countries for future growth in ESTs and the need for them to become more actively involved in future trade initiatives on environmental goods. The participation of LDCs in EST trade, however, is still limited and has remained more or less stagnant over the period 2006-2016. At the same time, the dominant EST sectors in world trade, namely renewable energy (in particular solar PV cells and modules) and wastewater management and water treatment, are also sectors that are immensely important from a sustainable development perspective. They are also important for the realization of goals such as climate change mitigation, ensuring energy access in rural areas and access to clean water and sanitation in the wider developing world, including LDCs.

The concentration of the EST industry in a relatively small number of developed and developing countries (mainly in Asia) raises questions about whether and how the growth of the EST industry can enable wider green economy-related benefits for a larger pool of developing countries and LDCs. This question is particularly relevant for developing countries with limited manufacturing and supply capacity for ESTs, weak regulatory frameworks (for both environment and investment) and skills and knowledge gaps.

The analysis in this report shows that, in order to further enable developing countries to fully harness the opportunities presented by EST trade and increase their engagement in related trade negotiations, a holistic approach is needed. This includes filling data and research gaps, awareness raising, capacity enhancement, and policy coherence at both national and global levels.

7.1. The need for better and more data

The basis of any informed decision-making, both for domestic and international policy makers, is sound data and analysis. However, the lack of clear definitions and data related to environmental goods and services still impedes a complete understanding of EST trade and value chains. Challenges include the lack of an international agreed upon definition of ESTs and the lack of data at a more disaggregated level.

To enable progress in terms of boosting trade in ESTs and expanding the reach of the benefits from trade, the following three aspects are essential.

Environmental credibility

Environmental credibility needs to be the underlying principle of any negotiating initiative, to ensure both true environmental benefits and buy-in by stakeholders. A more comprehensive sustainability assessment, demonstrating how a particular HS subheading or more specific product falling under the subheading fulfils important environmental and other sustainable development objectives, could help to achieve this credibility and facilitate discussions and negotiations. This is applies both at the broad level (for e.g. climate change mitigation and air pollution) and at the more micro-level (e.g. critical product used in a solar PV project, product used to reduce emissions in a coal-fired power plant or critical component used in a wind-power plant).

Accuracy

In order to establish environmental credibility, it is indispensable to be able to distinguish products with environmental end-uses from products with other end-uses. More granular classifications under distinct subheadings would enable better data collection and tracking of trade patterns for ESTs. It may not be possible in many cases for customs officials to physically distinguish such goods – like for instance in the case of solar hot water systems and solar cook stoves. Hence, trade initiatives that focus exclusively on the goods and services related to ESTs would benefit from a clearer and separate classification of certain goods and the creation of separate subheadings at the HS 6-digit level. An updating of classification for environmental services that matches the latest market developments and dynamics is also needed.

Coherence and availability

To enable international discussions and negotiations, definitions and classifications need to be harmonized. Efforts towards harmonizing product descriptions in national tariff lines beyond the HS 6-digit subheadings will help in better identifying market access opportunities and challenges, data gathering, and cross-country comparability of data. Data gathering in environmental services is also an enormous challenge and the lack of harmonized data sets and extreme paucity of data impedes a better understanding of the drivers and effects of trade in environmental services as well as correlation of environmental services trade flows with those of environmental goods.

Better and more accurate data, widely available and easily accessible datasets for ESTs together with harmonized product descriptions and revised services classification will greatly help in better understanding and analysis of the relationship between EST trade flows and their sustainable development impact, as well as the global value chains they are embedded in and facilitate informed decision-making by policy-makers.

7.2. Support measures at the country level

A holistic approach to trade governance implies the consideration of a number of elements as part of trade and complementary 'extra-trade' initiatives that enable the realization of environmental as well as green economy benefits, particularly for developing countries. Trade governance usually relies on trade negotiations as the driving vehicle for expanding trade in ESTs and relevant trade policies, rules and institutions as the regulatory frameworks to guide such trade. However, trade negotiations and regulatory frameworks should be informed not only by market access but also other needs and considerations such as environmental priorities and access to technology and finance. These are essential for market creation and enable ESTs trade flows to have a meaningful impact for both exporting as well as importing countries. Measures at the domestic level are required to pave the way for regional and global initiatives.

A first step for developing countries and LDCs towards harnessing the opportunities of EST trade would be a comprehensive assessment of their domestic environmental needs and priorities. A review of trade negotiations on environmental goods and services reveals that one reason for minimal or no engagement among a larger group of developing countries is a perceived lack of export opportunities, as a quid pro quo for making import-related commitments. Identifying specific areas where support is needed, based on individual country needs, could help in the design of technical assistance and cooperation arrangements. Such cooperation arrangements could be appended or attached to trade agreements. Examples of specific support areas may include identifying technologies that can have a beneficial environmental and sustainable development impact and assessing their overall impact based on the multi-dimensional criteria outlined in the sustainability assessment of this study. For instance, identifying increased investment opportunities in ESTs resulting from trade initiatives, addressing domestic environmental problems, generation of downstream services jobs, etc.

Such cooperation and technical assistance packages should go beyond pledges and be made contingent on deployment of country-specific measures, such as strengthening domestic environmental regulations, introduction of domestic regulatory frameworks required for environmental services, designing clean energy investment frameworks, and launching environment industry specific skills and job development programmes. In addition, multilateral development assistance organizations such as the United Nations Industrial Development Organization (UNIDO), the World Bank and ITC could help with building up the capacity and competitiveness of domestic EST industries, especially SMEs, and facilitate access to technologies that may be required. The availability of such 'incentive package' measures may enable developing countries, and indeed other countries, to approach trade negotiations on ESTs from more than a 'mercantilist' perspective and see it as an opportunity for a green economy transformation that is driven by both imports and exports. Renewable energy could be selected as a priority or 'model' sector for creating a template for such assistance packages, given the huge importance of the sector in EST trade flows, as identifies in this report. Renewable energy may also qualify based on the urgency of climate change mitigation and its relevance to other SDGs as highlighted in the sustainability assessment exercise.

Finally, trade negotiations on ESTs would be greatly aided by a greater degree of policy coherence and coordination among trade and environmental policy makers, as well as with the research community. This would ensure that trade commitments as well as related technical assistance and capacity building measures are responsive to environmental and broader sustainable development needs and priorities. It would also ensure that policy-makers get timely access to and benefit from relevant and cutting-edge research in the domain of ESTs. In this regard, inter-institutional partnerships and collaboration on policy-relevant research amongst international organizations, think tanks and academic institutions could prove highly valuable. Policy coherence at the national level could be achieved for example by cross ministry cooperation. Besides policy coherence between different sectors at the national level, coherence at the global level is also essential. This could be fostered by policy dialogue and the sharing of best practices and experiences.

7.3. Steps forward in global and regional trade governance

At the trade governance level, a clear shift in engagement of countries - both developed and developing – away from multilateral trade negotiations towards plurilateral and regional initiatives can be observed. Those regional and plurilateral trade initiatives can serve as stepping stones towards multilateral trade initiatives, particularly for middle-income developing countries and LDCs. Irrespective of the level at which the negotiations are taking place, the report finds some factors that would contribute to more beneficial and inclusive EST trade governance.

First of all, there is a need for an integrated approach to goods and services in the context of EST trade negotiations. They are often deployed jointly and cannot be clearly distinguished within one technology. Taking this connection into account would facilitate the discussion and trade of ESTs significantly. Furthermore, a more flexible approach is needed to ensure the engagement of countries that have concerns regarding sensitive products or industries, while at the same time maintaining environmental credibility. A good balance thus needs to be found between the elements of easy identification and justification from an environmental perspective; ease of identification as an environmental good at the customs level, particularly in the case of EPPs; criticality of application in an environmental end-use project; as well as sensitivities of countries with regard to imports whereby they may wish to have a longer or more phased reduction in tariffs or exemption from tariff reduction for certain products. The inclusion of products with export opportunities or of increased relevance to developing countries is also likely to address their perceived lack of export opportunities.

7.4. Concluding remarks and future research

All measures should take country-specific factors such as environmental needs and priorities, as well financial and technology-based needs into account to enable ESTs trade flows to have a meaningful impact for both exporting and importing countries. There is no one-size-fits-all approach that can be used by all countries to harness and maximize the opportunities of trade in ESTs. While this study is intended to support information-based decision-making by providing insights into general patterns and trends, an individual assessment at the country-level is still indispensable. Trade liberalization measures, whether plurilateral or regional, should also be mindful of the trade and value chain implications of including specific countries as well as specific ESTs and their related components.

Important questions remain for future research. First of all, more and better data should be collected to enable more in-depth analysis and inform policy-making, especially in the environmental services sector. This could include the assessment of trade flows at a more disaggregated level, as for example taking into account the different destinations of exports from each country or country group. Furthermore, researchers should look to further explore the full picture of technology trade and transfer, including foreign direct investment and licenses, etc. Based on this knowledge, capacity building and policy dialogue should be promoted. Vital to such efforts are the collaboration and exchange across disciplines, sectors and borders.

Annex

Annex 1 – Selection of ESTs for the analysis

The list is based on a review of existing environmental goods list and relevant literature on the topic of environmental goods and services trade in developing countries. Using the "Friends of the Earth" 153 List (2005) as a starting point, goods/ technologies/ products were added to or excluded from the list based on the criteria set by the literature and previous discussions in the project group.

Literature that guided the analysis included:

- Araya, M. (2016). The Relevance of the Environmental Goods Agreement in Advancing the Paris Agreement Goals and SDGs. A Focus on Clean Energy and Costa Rica's Experience. Geneva: International Centre for Trade and Sustainable Development.
- ASEAN-SHINE (2016). Scoping study on the Intra-ASEAN value chain cooperation and trade in energy efficiency and renewable energy technologies.
- ICTSD (2008). Liberalization of trade in environmental goods for climate change mitigation: The sustainable development context. Background paper, Trade and Climate Change Seminar, June 18-20, 2008, Copenhagen.
- Jha, V. (2008). Environmental Priorities and Trade Policy for Environmental Goods: A Reality Check. Geneva: International Centre for Trade and Sustainable Development.
- Knudson, H., Aspen, D.M. and Hermansen, J.E. (2015). An evaluation of environmental goods for the WTO Environmental Goods Agreement (EGA): EGs for developing countries. Trondheim: Norwegian University of Science and Technology.
- UNEP (2014). South-South Trade in Renewable Energy – A Trade Flow Analysis of Selected Environmental Goods. Geneva: United Nations Environment Programme.
- WTO (2005). Synthesis of submissions on environmental goods. Informal Note by the Secretariat TN/TE/W/63. Committee on Trade and Environment Special Session, 17 Nov 2005.

Based on discussions in the project group (18 May 2018) and a review of the literature and existing lists, the main ETS categories were identified as:

- Air pollution control (APC),
- Wastewater management (WWM),
- Solid and hazardous waste management (SHWM),
- Renewable energy (RE), and
- Environmentally preferable products (EPPs) specifically relevant to developing countries (these include both EPPs that are cleaner or more efficient technologies or products and those characterized by their end-use or disposal)

Environmental monitoring, analysis and assessment goods are not included in the list.

Table A1.1: List of EST-EGs included in the analysis

HS Code	HS Code Description	Ex-out / Additional Product Specification	Remarks / Environmental Benefit	Environmental product category	Lists / reports
			Air pollution control (APC)		
840420	Condensers for steam or other vapour power units		Used to cool gas streams to temperatures which allow the removal of contaminants, e.g. volatile organic compounds (VOC) like benzene.	Air pollution control	153 List APEC (Vladivostok)
840490	Parts for auxiliary plant for boilers, condensers for steam, vapour power unit.		Used to cool gas streams to temperatures which allow the removal of contaminants, e.g. volatile organic compounds (VOC) like benzene.	Air pollution control	APEC (Vladivostok)
840510	Producer gas or water gas generators, with or without their purifiers; acetylene gas generators and similar water process gas generators, with or without their purifiers	Include only those with purifiers	Purifiers remove contaminants (such as cyanide and sulphur compounds) produced in the manufacture of gases. Difficult to determine end-use.	Air pollution control	153 list
841410	Vacuum pumps		Air handling equipment. Used in a number of environmental applications, e.g. flue gas desulphurisation (the process by which sulphur is removed from combustion exhaust gas).	Air pollution control, Solid & hazardous waste management	153 list
841430	Compressors of a kind used in refrigerating equipment	Compressors used in air handling equipment	Lower water use, reduced sewage volumes, and less power consumption compared to regular gravity powered toilet systems	Air pollution control	153 list
841440	Air compressors mounted on a wheeled chassis for towing	Air compressors used in the transportation or extraction of polluted air, corrosive gases, or dust	Transport or extraction of polluted air, corrosive gases, or dust	Air pollution control	153 list
841459	Fans other than table, floor, wall, window, ceiling or roof fans, with a self-contained electric motor of an output not exceeding 125W	Fans for the transport or extraction of polluted air, corrosive gases, or dust	Fans for the transport or extraction of polluted air, corrosive gases, or dust	Air pollution control	153 list
841480	Air pumps, other than compressors and fans; ventilating/recycling hoods incorporating a fan, whether or not fitted with filters	Industrial hoods, aerators, blowers and diffusers	Transport or extraction of polluted air, corrosive gases, or dust	Air pollution control	153 list
841490	Parts of vacuum pumps, compressors, fans, blowers, hoods		Air handling equipment. Transport or extraction of polluted air, corrosive gases or dust	Air pollution control	153 list
841960	Machinery for liquefying air or other gases		For separation and removal of pollutants through condensation	Air pollution control	153 list, OECD, APEC (Vladivostock)

Table A1.1: List of EST-EGs included in the analysis (continued)

841989	Machinery, plant or laboratory equipment, whether or not electrically heated (excluding furnaces, ovens and other equipment of heading 85.14), for the treatment of materials by a process involving a change of temperature such as heating, cooking, roasting, distilling, rectifying, sterilising, pasteurising, steaming, drying, evaporating, vaporising, condensing or cooling, other than machinery or plant of a kind used for domestic purposes; instantaneous or storage water heaters, non-electric	Evaporators and dryers, for water and wastewater treatment. Condensers and cooling towers. Biogas reactors; digestion tanks and biogas refinement equipment.	For separation and removal of pollutants through condensation. Includes fluidised bed systems (bubbling, circulating, etc.) and biomass boilers. Can also help anerobic digestion of organic matter	Air pollution control Solid & hazardous waste management Wastewater and water management	153 list , OECD, APEC (Vladivostock)
842139	Filtering or purifying machinery and apparatus for gases; other than intake air filters for internal combustion engines	Optional ex-out: Catalytic converters / Gas separation equipment / Pneumatic fluid power filters rated at 550 kPa or greater / Industrial gas cleaning equipment / Electrostatic filters (precipitators)	Physical, mechanical, chemical or electrostatic filters and purifiers for removal of COV, solid or liquid particles in gases, etc.	Air pollution control	153 list, OECD, APEC (Vladivostok), UNEP (2014)
902610	Instruments and apparatus for measuring or checking the flow or level of liquid	Air quality monitors; dust emissions monitors	Physical, mechanical, chemical or electrostatic filters and purifiers for removal of COV, solid or liquid particles in gases, etc.	Air pollution control, Environmental monitoring, analysis & assessment	153 list, OECD, APEC (Vladivostok), UNEP (2014)
Solid and hazardous waste management (SHWM)					
392010	Other plates, sheets, film, foil and strip, of plastics, non-cellular and not reinforced, laminated, supported or similarly combined with other materials: of polymers of ethylene	HDPE or flexible membrane landfill liners and/or covers for methane collection; Geomembranes for soil protection, water tightness, anti-erosion, leachate protection	Flexible geomembranes of plastics used as landfill drainage mats, bottom liners and covers; also used in water containment contexts Difficult to determine end-use	Solid and hazardous waste management	153 list
560290	Felt, whether or not impregnated, coated, covered or laminated: other	Geosynthetic clay liners (GCLs)	Composite clay and geosynthetic liners used for landfill drainage and leachate protection; Geosynthetic layer attached to clay layer (often expansive bentonite clay) Difficult to determine end-use	Solid and hazardous waste management	
680620	Exfoliated vermiculite, expanded clays, foamed slag and similar expanded mineral materials (including intermixtures thereof)	Geosynthetic clay liners (GCLs)	Composite clay and geosynthetic liners used for landfill drainage and leachate protection; Geosynthetic layer attached to clay layer (often expansive bentonite clay)	Solid and hazardous waste management	
681599	Articles of stone or of other mineral substances (including carbon fibres, articles of carbon fibres and articles of peat), not elsewhere specified or included: other	Geosynthetic clay liners (GCLs)	Composite clay and geosynthetic liners used for landfill drainage and leachate protection; Geosynthetic layer attached to clay layer (often expansive bentonite clay)	Solid and hazardous waste management	

Table A1.1: List of EST-EGs included in the analysis (continued)

730900	Reservoirs, tanks, vats and similar containers for any material (other than compressed or liquefied gas), of iron or steel, of a capacity exceeding 300 l, whether or not lined or heat-insulated, but not fitted with mechanical or thermal equipment	Waste containers, drinking water storage containers	Possible uses: tanks for anaerobic digesters to turn biomass to gas; solar pre-heating storage tank; waste containers; storage of safe drinking water; septic tanks; tanks for wastewater treatment; waste containers for wastewater or sewage, hazardous waste, etc. Difficult to determine end-use	Solid and hazardous waste management, Wastewater management and water treatment	153
731010	Tanks, casks, drums, cans, boxes and similar containers, for any material (other than compressed or liquefied gas), of iron or steel, of a capacity not exceeding 300 l, whether or not lined or heat-insulated, but not fitted with mechanical or thermal equipment : Greater than 50l	Waste containers, drinking water storage containers	Possible uses: tanks for anaerobic digesters to turn biomass to gas; solar pre-heating storage tank; waste containers; storage of safe drinking water; septic tanks; tanks for wastewater treatment; waste containers for wastewater or sewage, hazardous waste, etc. Difficult to determine end-use	Solid and hazardous waste management, Wastewater management and water treatment	153
731021	Tanks, casks, drums, cans, boxes and similar containers, of a capacity not exceeding 300 l: To be closed by soldering or crimping	Waste containers, drinking water storage containers	Possible uses: tanks for anaerobic digesters to turn biomass to gas; solar pre-heating storage tank; waste containers; storage of safe drinking water; septic tanks; tanks for wastewater treatment; waste containers for wastewater or sewage, hazardous waste, etc. Difficult to determine end-use	Solid and hazardous waste management, Wastewater management and water treatment	153
731029	Tanks, casks, drums, cans, boxes and similar containers, of a capacity not exceeding 300 l: Other	Waste containers, drinking water storage containers	Possible uses: tanks for anaerobic digesters to turn biomass to gas; solar pre-heating storage tank; waste containers; storage of safe drinking water; septic tanks; tanks for wastewater treatment; waste containers for wastewater or sewage, hazardous waste, etc. Difficult to determine end-use	Solid and hazardous waste management	153
761290	Aluminum casks, drums, cans, boxes and similar containers for any material (other than compressed or liquefied gas), of a capacity not exceeding 300 l, whether or not lined or heat-insulated, but not fitted with mechanical or thermal equipment: other.	Waste containers, including those for municipal or dangerous waste	Possible uses: tanks for wastewater treatment; waste containers for wastewater or sewage, hazardous waste, etc. Difficult to determine end-use	Solid and hazardous waste management	153 list
840219*	Steam or other vapour generating boilers (other than central heating hot water boilers capable also of producing low pressure steam); super-heated water boilers: Other vapour generating boilers, including hybrid boilers	Biomass boilers	Powered by the boiling of renewable biomass, e.g. straw (residue from global agriculture) or municipal solid waste, to be converted to steam, and later, electricity	Solid and hazardous waste management	153 list
840290	Steam or other vapour generating boilers (other than central heating hot water boilers capable also of producing low pressure steam); super-heated water boilers:	Parts for 840219x		Solid and hazardous waste management	153 list, APEC (Vladivostok)
840410	Auxiliary plant for use with boilers of heading No. 8402 or 8403 (for example, economizers, super-heaters, soot removers, gas recoverers); condensers for steam or other vapour power units: auxiliary plant for use with boilers of heading No. 84.02 or 84.03	Auxiliary plant for use with 840219x	Components of industrial air pollution control plant which minimise the release of pollutants into the atmosphere.	Air pollution control, Solid and hazardous waste management	153 list, APEC

Table A1.1: List of EST-EGs included in the analysis (continued)

841320	Hand pumps, other than those of subheading 841311 or 841319		Facilitate the delivery of water or other liquids to the surface Examples: Hand pumps for the emptying of pits that store human waste Facilitate the delivery of water Examples: Treadle pumps (foot pumps) for irrigation, hand water pumps for drinking water pumping from wells and boreholes Difficult to determine end-use	Solid and hazardous waste management, Wastewater management and water treatment, Low environmental impact	153
841350	Reciprocating positive displacement pumps not elsewhere specified	Pumps for sewage and waste water treatment	For handling and transport of wastewater or slurries during treatment	Solid and hazardous waste management, Wastewater management and water treatment	153, OECD
841360	Other rotary positive displacement pumps	Pumps for sewage and waste water treatment	For handling and transport of wastewater or slurries during treatment	Solid and hazardous waste management, Wastewater management and water treatment	153, OECD. APEC
841370	Other centrifugal pumps	Centrifugal pumps lined to prevent corrosion; centrifugal sewage pumps	For handling and transport of wastewater or slurries during treatment	Solid and hazardous waste management, Wastewater management and water treatment	153, OECD, APEC
841780	Other industrial or laboratory furnaces and ovens, including incinerators, non-electric	Optional ex-outs may include: Waste incinerators or other waste treatment apparatus (heat or catalytic incinerators)	These products are sued to destroy solid and hazardous wastes. Catalytic incinerators are designed for the destruction of pollutants (such as VOC) by heating polluted air and oxidation of organic components. Incineration is necessary for certain types of waste (for example, medical waste). Incinerating solid waste kills disease-carrying organisms and reduces the volume and weight of the waste. COV destruction by heating of polluted air and oxidation of organic components. Biomass exploitation needs careful resource management if it is to be sustainable. Since practice can vary, examples chosen for this list focus on waste recovery (agricultural and forestry residues, biodegradable fraction of municipal solid waste). Difficult to determine end-use	Air pollution control, Solid and hazardous waste management, Wastewater management and water treatment	153 list, OECD, APEC (Vladivostok), UNEP (2014)
841790	industrial or laboratory furnaces and ovens, including incinerators, non-electric: Parts	Optional ex-out: Parts for 841780x		Air pollution control Solid and hazardous waste management, Wastewater management and Water treatment	153 list , OECD, APEC (Vladivostok), UNEP (2014)

Table A1.1: List of EST-EGs included in the analysis (continued)

841940	Distilling or rectifying plant	Optional ex-outs include: desalination systems; biogas refinement equipment; and solvent recycling plants	Desalination plants remove salt from water and are particularly important in conditions of water scarcity. Proper disposal of byproducts is also required. Biogas refinement equipment "upgrades" biogas resulting from organic matter to give it the same properties of natural gas. Allows the recovery of and reuse of solvents, e.g. solvents used in dry cleaning industries	Solid and hazardous waste management, Wastewater management and Water treatment	153 list, OECD, APEC
842220	Machinery for cleaning or drying bottles or other containers		Used to clean and dry bottles for recycling and reuse	Solid and hazardous waste management (recycling)	
842290	Parts for 842220			Solid and hazardous waste management	
842940	Tamping machines and road rollers, self-propelled	Tamping Machines and Road Rollers (specifically Self-propelled sanitary landfill compactors)	Used in solid waste treatment or recycling	Solid and hazardous waste management (recycling)	
846291	Hydraulic presses for working metal	Shredders/balers for metals; hydraulic		Solid and hazardous waste management (recycling)	153 list
847420	Crushing or grinding machines		Used for solid waste treatment and recycling; Including waste separators.	Solid and hazardous waste management (recycling)	153 list, APEC
847982	Mixing, kneading, crushing, grinding, screening, sifting, homogenising, emulsifying or stirring machines		Used to prepare waste for recycling: mixing of wastewater during treatement Used to prepare organic waste for composting. Composting converts organic waste into humus, which can be used as fertiliser. Composting can minimise the amount of waste going to landfill as well as recovering the valuable nutrient and energy content of the waste.	Solid and hazardous waste management (recycling) Wastewater management and Water treatment	153 list, APEC (Vladivostok)
847989	Machines and mechanical appliances having individual functions, not specified or included elsewhere in this Chapter		Machines and appliances designed for a wide range of areas of environmental management including waste, waste water, drinking water production and soil remediation. In-vessel composting systems can handle large amounts of waste and speed up decomposition. Trash compactors reduce the volume of solid waste, allowing more efficient transport and disposal.	Solid and hazardous waste management (recycling) Wastewater management and Water treatment	153 list, APEC (Vladivostok)

Table A1.1: List of EST-EGs included in the analysis (continued)

847990	Parts of machines and mechanical appliances of 8479	Parts for 847982x and 847989x		Solid and hazardous waste management (recycling) Wastewater management and Water treatment	153 list, APEC (Vladivostok)
851410	Resistance heaters furnaces and ovens	Waste incinerators or other (heat) waste treatment apparatus	Destruction of pollutants (such as VOC) by heating polluted air and oxidation of organic components.	Air pollution control Solid and hazardous waste management	153 list, APEC (Vladivostok)
851420	Furnaces and ovens; functioning by induction or dielectric loss	Waste incinerators or other (heat) waste treatment apparatus	Destruction of pollutants (such as VOC) by heating polluted air and oxidation of organic components.	Air pollution control Solid and hazardous waste management	153 list
851430	Other furnaces and ovens	Waste incinerators or other (heat) waste treatment apparatus	Destruction of pollutants (such as VOC) by heating polluted air and oxidation of organic components.	Air pollution control Solid and hazardous waste management	OECD APEC (Vladivostok), UNEP (2014)
851490	Parts	Parts for 851410x, 851420x and 851430x		Air pollution control, Solid and hazardous waste management	153 list , OECD, APEC (Vladivostok), UNEP (2014)
			Wastewater management and water treatment (WWM)		
391400	Ionexchangers based on polymers of headings 39.01 to 39.13, in primary forms.	Ionexchangers used in water purification systems		Wastewater management and Water treatment	
392290	Bidets, lavatory pans, flushing cisterns and similar sanitary ware, of plastics	Resource efficient sanitary fixtures including composting toilets, dry closets, waterless urinals, vacuum toilets	Toilets/urinals that use little to no water; In composting systems, human waste can be composted for later use as chemical free fertilizer	Wastewater management and Water treatment, Environmentally Preferable Products, Cleaner techs or products	
392510	Reservoirs, tanks, vats and similar containers, of a capacity exceeding 300 l	Tanks for storage of drinking and potable water	Example: A-Aqua's foldable water storage tanks made of PVC coated fabric ("pillow tank" for drinking water and "onion tank" for potable water)	Wastewater management and Water treatment	
560314	Nonwovens, whether or not impregnated, coated, covered or laminated, Weighing more than 150 g/m²	Landfill drainage mats of fabric of polyethylene, polypropylene or nylon for filtering waste water; filter cloth; filter sleeve	Flexible geomembranes of plastics used as landfill drainage mats and liners to protect groundwater sources from leachate; also used in water containment contexts	Wastewater management and Water treatment Solid and hazardous waste management	153 list
591190	Textile products and articles, for technical uses, specified in Note 7 to this Chapter. Filter bags and similar for use in purifying plants		Solids separation treatment, industrial and municipal wastewater applications including sludge processes, stormwater treatment, aquaculture, food processing, etc. Example: Salsnes wastewater filters	Wastewater management and Water treatment	

Table A1.1: List of EST-EGs included in the analysis (continued)

691010	Ceramic sinks, wash basins, wash basin pedestals, baths, bidets, water closet pans, flushing cisterns, urinals and similar sanitary fixtures of porcelain or china	Resource efficient sanitary fixtures including composting toilets, dry closets, waterless urinals, vacuum toilets	Toilets/urinals that use little to no water; In composting systems, human waste can be composted for later use as chemical free fertilizer	Wastewater management and Water treatment Environmentally Preferable Products Cleaner techs or products	153
732490	Sanitary ware and parts thereof, or iron or steel	Water saving shower head, dry closets, composting toilets, vacuum toilets		Wastewater management and Water treatment Environmentally Preferable Products Cleaner techs or products	153
820750	Interchangeable tools for hand tools, whether or not power-operated, or for machine-tools (for example, for pressing, stamping, punching, tapping, threading, drilling, boring, broaching, milling, turning or screw driving): Tools for drilling, other than rock drilling	For the drilling of drinking water wells and bore holes	Provides access to drinking water and other groundwater sources located meters under the surface	Wastewater management and Water treatment	
820760	Interchangeable tools for hand tools, whether or not power-operated, or for machine-tools (for example, for pressing, stamping, punching, tapping, threading, drilling, boring, broaching, milling, turning or screw driving): Tools for boring or broaching	For the drilling of drinking water wells and bore holes	Provides access to drinking water and other groundwater sources located meters under the surface	Wastewater management and Water treatment	
841381	Pumps for liquids, whether or not fitted with a measuring device	Pumps powered by renewable energy sources, for example, integrated with wind turbines or solar pumping systems	Help deliver clean water through the use of renewable energy Examples: Small scale – pump for irrigation or watering livestock; Industrial scale – pumps as integral component of water treatment plants	Wastewater management and Water treatment	153
841939	Dryers, other	Sludge dryers	Device used in WWM, which requires sludge to be treated	Wastewater management and Water treatment	APEC (Vladivostok)
842121	Filtering or purifying machinery and apparatus for liquids: for filtering or purifying water		Used to filter and purify water for a variety of applications	Wastewater management and Water treatment	153, OECD, APEC (Vladivostok), UNEP (2014)
842129	Filtering or purifying machinery and apparatus for liquids; other		Used to remove contaminants from wastewater, by chemical recovery, oil/water separation, screening or straining.	Wastewater management and Water treatment	153, OECD, APEC (Vladivostok), UNEP (2014)
842199	Parts of filtering or purifying machinery and apparatus for liquids or gases	Parts for 842121x and 842129x	Including sludge belt filter presses and belt thickeners	Wastewater management and Water treatment	153, OECD, APEC (Vladivostok)
842833	Other continuous - action elevators and conveyors, for goods or materials; other, belt type		For transport of waste around the treatment plant.	Wastewater management and Water treatment	153, APEC

Table A1.1: List of EST-EGs included in the analysis (continued)

848110 to 848180	Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like, including pressure-reducing valves and thermostatically controlled valves: Other appliances	Taps and valves for the delivery of clean drinking water in developing countries and emergency situations	Examples: Water Station Taps	Wastewater management and Water treatment	153
848130	Check (non-return) valves		For handling and transport of wastewater or slurries during treatment	Wastewater management and Water treatment	153, OECD
848140	Safety or relief valves		For handling and transport of wastewater or slurries during treatment	Wastewater management and Water treatment	153, OECD
854370	Other electrical machines and apparatus having individual functions (not specified elsewhere in chapter 85)	Ozone generators for water purification	Ozone purification used as alternative to chlorine; may be expensive for wide use in developing contexts	Wastewater management and Water treatment	
854389	Electrical machines and apparatus, having individual functions, not specified or included elsewhere in this chapter; other	Ozone production system; Ultraviolet water disinfection/ treatment systems		Wastewater management and Water treatment	153, APEC, OECD
854390	Parts	Parts for 854390x		Wastewater management and Water treatment	153, APEC (Vladivostok), OECD
			Clean up or remediation of soil and water (C/R)		
842119	Centrifuges, including centrifugal dryers; filtering or purifying machinery and apparatus, for liquids or gases: Other	Oil skimmers	Help to clean-up and separate oil from water	Environmental remediation and clean-up	153 list, OECD, APEC
842191	Parts for 842119			Environmental remediation and clean-up	153 list, OECD, APEC
851629	Electric space heating apparatus and electric soil heating apparatus; other	Electric space heating and soil heating apparatus	Use heat to disinfect or remove organic compounds (e.g. pesticides, hydrocarbons) from soil, and to dry contaminated soil prior to treatment processes.	Environmental remediation and clean-up	153 list, OECD
890790	Other floating structures	Pollution protection booms, oil absorbent booms, oil containment booms	Floating barriers to oil can prevent an oil slick from reaching sensitive locations or spreading out further. Oil absorbents soak up and remove the oil.	Environmental remediation and clean-up	153 list, APEC
730820	Towers and lattice masts	Wind turbine towers and masts	Used to elevate and support wind turbine for generation of energy	Cleaner and renewable energy	153 list, UNEP (2014)
840211	Watertube boilers with a steam production exceeding 45 t per hour	To produce bioenergy	Difficult to determine end-use.	Cleaner and renewable energy	WTO
840212	Watertube boilers with a steam production not exceeding 45 t per hour	To produce bioenergy	Difficult to determine end-use.	Cleaner and renewable energy	WTO

Table A1.1: List of EST-EGs included in the analysis (continued)

840219	Other vapour generating boilers, including hybrid boilers	Biomass boilers; To produce bioenergy	Difficult to determine end-use.	Cleaner and renewable energy	WTO
840220	Superheated water boilers	To produce bioenergy	Difficult to determine end-use.	Cleaner and renewable energy	WTO
840310	Central heating water boilers other than those of heading 84.02	To produce bioenergy	Difficult to determine end-use.	Cleaner and renewable energy	WTO
840390	Parts for 840310	To produce bioenergy	Difficult to determine end-use.	Cleaner and renewable energy	WTO
840410	Auxiliary plant for use with boilers of heading 84.02 or 84.03 (for example, economizers, super-heaters, soot removers, gas recoverers); condensers for steam or other vapour power units		Difficult to determine end-use.	Cleaner and renewable energy, Air pollution control	APEC (Vladivostok), UNEP (2014)
840510	Producer gas or water gas generators, with or without their purifiers; acetylene gas generators and similar water process gas generators, with or without their purifiers	To produce bioenergy	Difficult to determine end-use.	Cleaner and renewable energy	APEC
840590	Parts for 840510	To produce bioenergy	Difficult to determine end-use.	Cleaner and renewable energy	APEC
840681	Steam and other vapor turbines of an output exceeding 40 MW	Turbines used for renewable energy processes	Turbines used in geothermal, wind, solar thermal, biomass power production	Cleaner and renewable energy	WTO
840682	Steam and other vapor turbines of an output not exceeding 40 MW	Turbines used for renewable energy processes	Turbines used in geothermal, wind, solar thermal, biomass power production	Cleaner and renewable energy	WTO
840690	Parts for steam and other vapour turbines	Parts suitable for US with stationary steam turbines over 40MW, stationary steam turbines not over 40 MW, other vapour turbines.	Difficult to determine end-use.	Cleaner and renewable energy	WTO, APEC (Vladivostok)
841011	Hydraulic turbines, water wheels, and regulators therefor, Of a power not exceeding 1,000 kW	For hydropower energy generation	Used in hydroelectric power generation, which produces no greenhouse gas emissions.	Cleaner and renewable energy	OECD, APEC, UNEP (2014)
841012	Hydraulic turbines, water wheels, and regulators therefor, Of a power exceeding 1,000 kW but not exceeding 10,000 kW	For hydropower energy generation	Used in hydroelectric power generation, which produces no greenhouse gas emissions.	Cleaner and renewable energy	OECD, APEC, UNEP (2014)
841013	Hydraulic turbines, water wheels, and regulators therefor, Of a power exceeding 10,000 kW	For hydropower energy generation	Used in hydroelectric power generation, which produces no greenhouse gas emissions.	Cleaner and renewable energy	OECD, APEC, UNEP (2014)
841090	Parts for 841011, 841012, 841013	For hydropower energy generation	Used in hydroelectric power generation, which produces no greenhouse gas emissions.	Cleaner and renewable energy	OECD, APEC, UNEP (2014)
841182	Gas turbines of a power exceeding 5,000 kW	Other gas turbines exceeding 5,000 kW, e.g. trubines that burn natural gas or recovered landfill gas	Gas turbines for electrical power generation from recovered landfill gas, coal mine vent gas or biogas.	Cleaner and renewable energy	APEC (Vladivostok)

Table A1.1: List of EST-EGs included in the analysis (continued)

841199	Parts of gas trubines		Parts for turbines described above	Cleaner and renewable energy	APEC (Vladi-vostok)
841919	Other instantaneous or storage water heaters, non-electric	Solar water heaters	Uses solar thermal energy to heat water, producing no pollution. Use of solar water heating displaces the burning of other, pollution-creating fuels.	Cleaner and renewable energy	OECD, APEC (Vladivostok), UNEP (2014)
841950	Heat exchange units, industrial type	Solar collector and solar system controller. Heat exchanger.	Solar thermal energy	Cleaner and renewable energy	OECD , APEC
841990	Parts of machinery, plant and equip-ment of heading No 84.19	Solar flat plate col-lector and social evacuated tube collector	Solar thermal energy	Cleaner and renewable energy	ASEAN, SHINE (2016), APEC (Vladivostok)
848610	Machines and apparatus for the man-ufacture of boules or wafers	Machines for the production of silicon boules and wafers for use in PV cells		Cleaner and renewable energy	
850161	AC generators of an output not ex-ceeding 75 kVA	To be used with turbines and generators in com-bination to produce electricity from renewable energy sources	Only to be used with renewable energy sources	Cleaner and renewable energy	WTO
850162	AC generators of an output exceeding 75 kVA but not exceeding 375 kVA	To be used with turbines and generators in com-bination to produce electricity from renewable energy sources	Only to be used with renewable energy sources	Cleaner and renewable energy	WTO
850163	AC generators of an output exceeding 375 kVA but not exceeding 750 kVA	To be used with turbines and generators in com-bination to produce electricity from renewable energy sources	Only to be used with renewable energy sources	Cleaner and renewable energy	WTO
850164	AC generators of an output exceeding 750 kVA	To be used with turbines and generators in com-bination to produce electricity from renewable energy sources	Only to be used with renewable energy sources	Cleaner and renewable energy	WTO, APEC (Vladivostok)
850300	Parts suitable for use solely or prin-cipally with the machines of heading 85.01 or 85.02	Parts for gen-erators used to produce electricity from renewable energy sources		Cleaner and renewable energy	APEC (Vladi-vostok)
850231	Other electric generating sets and rotary converters; wind-powered		Electricity generation from a renew-able resource (wind).	Cleaner and renewable energy	APEC (Vladi-vostok), UNEP (2014)

Table A1.1: List of EST-EGs included in the analysis (continued)

850239	Other electric generating sets and rotary converters	Small hydro powered generating plant: generator for use in the above hydro-power plant	Due to their negative environmental impact, large hydro-power plants are excluded from this category. The economic potential of small hydro power plants (<10MW), if correctly planned, is far more important.	Cleaner and renewable energy	WTO, OECD, APEC (Vladivostok)
850421	Electrical transformers; liquid dielectric, having a power handling capacity not exceeding 650kVA	Wet type distribution transformers	Only to be used with renewable energy sources		ASEAN, SHINE (2016)
850422	Electrical transformers; liquid dielectric, having a power handling capacity exceeding 650kVA but not exceeding 10,000kVA		Only to be used with renewable energy sources		ASEAN, SHINE (2016)
850440	Static converters	When used in conjunction with solar panels or wind turbines	Static converters are used with solar panels and wind turbines to produce electricity from renewable sources	Cleaner and renewable energy	
854140	Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes	PV module, wafers, cells		Cleaner and renewable energy	UNEP (2014), WTO, ASEAN, SHINE (2016), APEC (Vladivostok)
854190	Parts for 854140 – photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes	PV cell parts		Cleaner and renewable energy	
900190	Optical fibres and optical fibre bundles; optical fibre cables other than those of heading 85.44; sheets and plates of polarising material; lenses (including contact lenses), prisms, mirrors and other optical elements, of any material, unmounted: Other	Fresnel mirrors	Reflective solar collectors/cells, like those used in solar water heaters, or concentrated solar power (CHP). > Heliostats (HS 901380)	Cleaner and renewable energy	WTO
900290	Lenses, prisms, mirrors and other optical elements, of any material, mounted, being parts of or fittings for instruments or apparatus, other than such elements of glass not optically worked: Other	Fresnel reflector modules	Reflective solar collectors/cells, like those used in solar water heaters, or concentrated solar power (CHP). > Heliostats (HS 901380)	Cleaner and renewable energy	WTO
901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)	Optical instruments and then mention Optical instruments and then mention solar heliostats in brackets in brackets	Heliostats orient mirrors in concentrated solar power systems to reflect sunlight on receiver Difficult to determine end-use.	Cleaner and renewable energy	APEC (Vladivostok)
290511	Methanol		Methanol is a low pollution fuel, producing emissions low in reactive hydrocarbons and toxic compounds. It can also be produced sustainably from biomass. It is also a component in biodiesel manufacture.	EPPs, Cleaner Technologies and products	OECD
292218	Amino-alcohols, other than those containing more than one kind of oxygen function; their ethers and esters; salts thereof, 2-(N,N- Diisopropylamino)	Ethanol		EPPs, Cleaner Technologies and products	

Table A1.1: List of EST-EGs included in the analysis (continued)

382490	Products, preparations and residual products of the chemical or allied industries, not elsewhere specified or included: other	Biodiesel	Biodiesel is renewable fuel derived from vegetable oils or animal fats, suitable as a diesel fuel substitute or diesel fuel additive or extender. The fuel can be used in standard compression-ignition (i.e. diesel) engines with small or no modifications. It is biodegradable, non-toxic, and essentially free of sulphur, aromatic hydrocarbons (such as carcinogenic benzene), and produces far less particulate matter during combustion.	EPPs, Cleaner Technologies and products	OECD
441872	Other assembled flooring Panels, Multilayer, of bamboo		Renewable bamboo-based products are substitutions of wooden necessities. Since bamboo is characterized by short growing cycle, these environmentallty-friendly products can save a great deal of water, soil and air resources.	Environmentally Preferable Products, end-use	APEC (Vladivostok)
460129	Mats, matting and screens of vegetable materials: Other	From sustainable vegetable materials	Can be used to line water wells in developing countries. Also good for drainage purposes and erosion control	Environmentally Preferable Products, end-use	
482361	Trays, dishes, plates, cups and the like, of paper or paperboard: of bamboo		Biodegradable and more sustainable than disposable paper items. Come from sustainable sources	Environmentally Preferable Products, end-use	
530310	Jute and other textile bast fibers, raw or processed, but not spun, excluding flax, true hemp and ramie: raw or retted		Comes from sustainable sources and is biodegradable; used in packaging and woven fabric	Environmentally Preferable Products, end-use	
530110	Flax, raw or processed but not spun: raw or retted		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products, end-use	
530121	Flax, raw or processed but not spun: broken or scotched		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products, end-use	
530129	Flax, raw or processed but not spun: other		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products, end-use	
530390	Jute and other textile bast fibers, raw or processed, but not spun, excluding flax, true hemp and ramie: other		Comes from sustainable sources and is biodegradable; used in packaging and woven fabric	Environmentally Preferable Products, end-use	
530500	Coconut, abaca (Manila hemp or Musa textilis Nee), ramie and other vegetable textile fibres, not elsewhere specified or included, raw or processed but not spun; tow, noils and waste of these fibres (including yarn waste and garnetted stock), raw of processed but not spun		Comes from sustainable sources and is biodegradable; used in textiles and recycled paper	Environmentally Preferable Products, end-use	
530610	Flax yarn: single		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products	

Table A1.1: List of EST-EGs included in the analysis (continued)

530620	Flax yarn: multiple (folded) or cabled		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products	
530710	Yarn of jute or other textile bast fibers of heading 53.03: single			Environmentally Preferable Products	
530720	Yarn of jute or other textile bast fibers of heading 53.03: multiple (folded) or cabled			Environmentally Preferable Products	
530911	Woven fabrics of flax, containing 85% or more by weight of flax: unbleached or bleached		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products	
530919	Woven fabrics of flax, containing 85% or more by weight of flax: other		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products	
530921	Woven fabrics of flax, containing less than 85% by weight of flax: unbleached or bleached		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products	
530929	Woven fabrics of flax, containing less than 85% by weight of flax: other		Flax requires less water and fewer pesticides than cotton; price to produce flax is less than cotton	Environmentally Preferable Products	
531010	Woven fabrics of jute or of other textile bast fibers: unbleached			Environmentally Preferable Products	
531090	Woven fabrics of jute or of other textile bast fibers: other			Environmentally Preferable Products	
560710	Twine, cordage, ropes and cables, whether or not plaited or braided; whether or not impregnated, coated, covered or sheathed with rubber or plastics, of jute or other textile based fibers (of heading 53.03)		More biodegradable than synthetic fibers and made from renewable resources	Environmentally Preferable Products	
560721	Twine, cordage, ropes and cables, whether or not plaited or braided; whether or not impregnated, coated, covered or sheathed with rubber or plastics, of sisal or other textiles fibers of the genus Agave: binder or baler twine		More biodegradable than synthetic fibers and made from renewable resources [often sisal]	Environmentally Preferable Products	
560729	Twine, cordage, ropes and cables, whether or not plaited or braided; whether or not impregnated, coated, covered or sheathed with rubber or plastics, of sisal or other textiles fibers of the genus Agave: other			Environmentally Preferable Products	
560900	Articles of yarn, strip or the like of heading 54.04 or 54.05, twine, cordage, rope or cables, not elsewhere specified or included			Environmentally Preferable Products	
630510	Sacks and bags, of a kind used for the packing of goods of jute or other textile based fibers (of heading 53.03)		More biodegradable than synthetic fibers and made from renewable resources	Environmentally Preferable Products	153
680800	Panels, boards, tiles, blocks and similar articles of vegetable fibre, of straw or of shavings, chips	Panels, boards, tiles of sustainable vegetable fibers, straw or shavings		Environmentally Preferable Products	

Table A1.1: List of EST-EGs included in the analysis (continued)

732111	Stoves, ranges, grates, cookers, barbecues, braziers, gas-rings, plate warmers and similar non-electric domestic appliances, and parts thereof, of iron or steel: for gas fuel or for both gas and other fuels	Solar powered stoves/ appliances	Solar energy for cooking: no pollution, renewable energy source, allows preservation of firewood, suitable for off-grid usage	EPPs, Cleaner Technologies and products	153 list OECD APEC
732190	Parts for 732111			EPPs, Cleaner Technologies and products	153 list
732290	Air heaters and hot air distributors, (not electrically heated), incorporating a motor-driven fan or blower and parts thereof, of iron or steel	Solar air heaters		EPPs, Cleaner Technologies and products	
850680	Other primary cells and primary batteries	Fuel cells	Fuel cells use hydrogen or hydrogen-containing fuels such as methane to produce an electric current, through a electrochemical process rather than combustion. Fuel cells are clean, quiet, and highly efficient sources of electricity.	EPPs, Cleaner Technologies and products	153 OECD
851310	Portable electric lamps designed to function by their own source of energy (for example, dry batteries, accumulators, magnetos), other than lighting equipment of heading 85.12.		Solar lamps traded under the HS codes: 851310, 940540 and 940550 Examples include solar powered lamps and gravity powered lights	Environmentally Preferable Products	
853931	Electric filament or discharge lamps: Fluorescent, hot cathode	Fluorescent lights	Keep in mind that these are more efficient than halogen bulbs, but less efficient than LEDs	Environmentally Preferable Products	
940151	Furniture, seats: of bamboo or rattan	Seats of bamboo	Rattan is not a sustainable material	Environmentally Preferable Products	
940381	Other furniture and parts thereof: of bamboo or rattan	Other furniture and parts thereof of bamboo	Rattan is not a sustainable material	Environmentally Preferable Products	
940510	Chandeliers and other electric ceiling or wall light fittings; excluding those used for lighting public open spaces or thoroughfares			Environmentally Preferable Products	ASEAN (2016)
940540	Other electric lamps and lighting fittings	Solar powered lamps and fittings	Solar lamps traded under the HS codes: 851310, 940540 and 940550	Environmentally Preferable Products	ASEAN (2016)
940550	Non-electric lamps	Solar powered lamps and fittings	Solar lamps traded under the HS codes: 851310, 940540 and 940550	Environmentally Preferable Products	

Table A1.2: List of EST-EGs with clearer environmental end-use (selected ESTs)

HS subheading (6-digit)	HS 6-digit description	Classification	Justification
854140	Electrical apparatus; photo sensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light emitting diodes	Renewable Energy (Solar PV)	Solar PV cells and modules and share the sub-heading only with LEDs both of which have environmental relevance (clean-energy and energy-efficiency). Relevance to climate change mitigation
850231	Electric generating sets; wind-powered, (excluding those with spark-ignition or compression-ignition internal combustion piston engines)	Renewable Energy (Wind)	Clear correspondence of wind-powered generating sets with entire HS 6-digit subheading. Relevance to climate change mitigation.
841919	Heaters; instantaneous or storage water heaters, non-electric, other than instantaneous gas water heaters	Renewable Energy (Solar thermal)	The HS subheading contains solar water heaters together with other non-electric water heaters. But given the relevance for energy savings and climate-change mitigation, clear physical identification and manufacture in many developing countries, this sub-heading is included.
841011	Turbines; hydraulic turbines and water wheels, of a power not exceeding 1000kW	Renewable Energy (Small-hydro)	Clear correspondence with HS 6-digit subheading. Relevance to climate-change mitigation. Small hydro has a lower environmental impact compared to large-hydro. Intensification seen in South-South trade (UNEP 2014 report).
841012	Turbines; hydraulic turbines and water wheels, of a power exceeding 1000kW but not exceeding 10000kW	Renewable Energy (Small-hydro)	Clear correspondence with HS 6-digit subheading. Relevance to climate-change mitigation. Small hydro has a lower environmental impact compared to large-hydro. Intensification seen in South-South trade (UNEP 2014 report).
841090	Turbines; parts of hydraulic turbines and water wheels, including regulators	Spare parts (Renwable Energy-Small-hydro). Possible multiple end-uses.	Critical in small-hydro value-chain and potential for developing country exports. Intensification seen in South-South trade (UNEP 2014 report).
730820	Iron or steel; structures and parts thereof, towers and lattice masts	Renewable Energy-Wind Ex-out: Wind-turbine towers. Spare part. Possible multiple end-uses.	Critical in wind-energy value-chain. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).
848340	Gears and gearing, other than toothed wheels, chain sprockets and other transmission elements presented separately; ball or roller screws; gear boxes and other speed changers, including torque converters	Renewable Energy-Wind. Ex-out gear box. Spare part Possible multiple end-uses.	Critical in wind-energy value-chain. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).
848210	Ball bearings	Renewable Energy-Wind. Spare part. Multiple end-uses.	Critical in wind-energy value-chain. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).
848220	Tapered roller bearings, including cone and tapered roller assemblies	Renewable Energy-Wind. Spare part. Multiple end-uses.	Critical in wind-energy value-chain. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).

Table A1.2: List of EST-EGs with clearer environmental end-use (selected ESTs) continue

848230	Spherical roller bearings	Renewable Energy-Wind. Spare part. Multiple end-uses.	Critical in wind-energy value-chain. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).
848240	Needle roller bearings	Renewable Energy-Wind. Spare part. Multiple end-uses.	Critical in wind-energy value-chain. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).
848250	Other cylindrical roller bearings	Renewable Energy-Wind. Spare part.Multiple end-uses.	Critical in wind-energy value-chain. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).
848280	Other, including combined ball/roller bearings	Renewable Energy-Wind. Spare part. Multiple end-uses.	Critical in wind-energy value-chain. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).
850300	Parts suitable for use solely or principally with the machines of heading 85.01 or 85.02.	Renewable Energy-Wind. Spare part. Multiple end-uses.	Included in APEC list. Acc to UNEP South-South paper (2014) evidence suggests Evidence suggests that several developing countries are particularly competitive in wind components (for example, developing countries account for a high proportion of US imports of wind-specific components).
842139	Machinery; for filtering or purifying gases, other than intake air filters for internal combustion engines	Air-Pollution Control	More or less clear correspondence with HS 6-digit subheading. Included in UNEP South-South paper
842121	Machinery; for filtering or purifying water	Wastewater management and water treatment	Clear correspondence with HS 6-digit subheading. Included in UNEP South-South paper.
842129	Machinery; for filtering or purifying liquids, n.e.c. in item no. 8421.2	Wastewater management and water treatment	More or less clear correspondence with HS 6-digit subheading. Included in UNEP South-South paper
851410	Furnaces and ovens; electric, for industrial or laboratory use, resistance heated	Solid waste management Optional ex-outs may include: waste incinerators and heat or catalytic incinerators. Multiple end-uses likely	Included for analysis in UNEP South-South paper. Included in APEC list
851420	Furnaces and ovens; electric, for industrial or laboratory use, functioning by induction or dielectric loss	Solid waste management. Optional ex-outs may include: waste incinerators and heat or catalytic incinerators. Multiple end-uses likely	Included for analysis in UNEP South-South paper. Included in APEC list
851430	Furnaces and ovens; electric, for industrial or laboratory use, other than those functioning by induction, dielectric loss	Solid waste management. Optional ex-outs may include: waste incinerators and heat or catalytic incinerators. Multiple end-uses likely.	Included for analysis in UNEP South-South paper. Included in APEC list

Annex2 – RTAs related to environmental goods and services

Table A2.1: RTAs notified to the WTO mentioning environmental goods

1	Canada – Colombia (environmental cooperation agreement)	13.	EU - Korea, Republic of
2	Canada – Peru (environmental cooperation agreement)	14.	EU - Rep. of Moldova
3	Canada-Korea (environmental cooperation agreement)	15.	EU - Ukraine
4	EFTA – Albania	16.	East African Community (EAC) (Protocol on environment)
5	EFTA - Central America (Costa Rica and Panama)	17.	India - Japan
6	EFTA - Hong Kong, China	18.	Japan - Switzerland
7	EFTA – Montenegro	19.	Korea, Republic of - Turkey
8	EFTA-Bosnia and Herzegovina	20.	Korea-Australia
9	EU - CARIFORUM States EPA	21.	Latin American Integration Association (LAIA) (Argentina- Brazil-Uruguay cooperation agreement)
10	EU - Central America	22.	New Zealand - Chinese Taipei
11	EU - Colombia and Peru	23.	New Zealand- Korea Republic of
12	EU – Georgia		

Table A2.2: RTAs notified to the WTO mentioning environmental services

1. ASEAN - Australia - New Zealand	36. EFTA – Colombia	71. Mexico - Central America
2. ASEAN - China	37. EFTA - Hong Kong, China	72. New Zealand - Chinese Taipei
3. ASEAN - Korea, Republic of	38. EFTA - Korea, Republic of	73. New Zealand - Malaysia
4. Australia - Chile	39. EFTA – Mexico	74. New Zealand-Korea
5. Australia - China	40. EFTA - Singapore	75. Nicaragua and the Separate Customs Territory of Taiwan, Penghu, Kinmen and Matsu
6. Australia - New Zealand (ANZCERTA)	41. EFTA - Ukraine	76. North American Free Trade Agreement (NAFTA)
7. Brunei Darussalam - Japan	42. EU - CARIFORUM States EPA	77. Pakistan - China
8. Canada - Chile	43. EU - Central America	78. Pakistan - Malaysia
9. Canada - Colombia	44. EU – Chile	79. Panama - Chile
10. Canada - Peru	45. EU - Colombia and Peru	80. Panama - Costa Rica (Panama - Central America)
11. Canada-Korea	46. EU - Georgia	81. Panama - Nicaragua (Panama - Central America)

Table A2.2: RTAs notified to the WTO mentioning environmental services (continued)

12. Chile - China	47. EU - Korea, Republic of	82. Panama - Peru
13. Chile - Colombia	48. EU - Mexico	83. Panama - Singapore
14. Chile - Costa Rica (Chile - Central America)	49. EU - Rep. of Moldova	84. Peru - Chile
15. Chile - El Salvador (Chile - Central America)	50. EU - Ukraine	85. Peru - China
16. Chile - Guatemala (Chile - Central America)	51. Eurasian Economic Union	86. Peru - Korea, Republic of
17. Chile - Honduras (Chile - Central America)	52. European Economic Area (EEA)	87. Peru - Mexico
18. Chile - India	53. European Free Trade Association (EFTA)	88. Peru - Singapore
19. Chile - Japan	54. Hong Kong, China - Chile	89. Rep. of Korea - Viet Nam
20. Chile - Mexico	55. Hong Kong, China - New Zealand	90. Singapore - Australia
21. China - Costa Rica	56. Iceland - China	91. Singapore - Chinese Taipei
22. China - Hong Kong, China	57. India - Malaysia	92. Singapore- GCC (Gulf Co-operation Council)
23. China - Macao, China	58. Israel - Mexico	93. Southern Common Market (MERCOSUR)
24. China - New Zealand	59. Japan - Malaysia	94. Switzerland - China
25. China - Rep. of Korea	60. Japan - Mongolia	95. Thailand - Australia
26. China - Singapore	61. Japan - Peru	96. Trans-Pacific Strategic Economic Partnership
27. Colombia - Mexico	62. Japan - Singapore	97. Ukraine - Montenegro
28. Colombia - Northern Triangle (El Salvador, Guatemala, Honduras)	63. Japan - Switzerland	98. US - Chile
29. Costa Rica - Peru	64. Korea - Colombia	99. US - Colombia
30. Costa Rica - Singapore	65. Korea, Republic of - Chile	100. US - Jordan
31. Dominican Republic - Central America	66. Korea, Republic of - India	101. US - Morocco
32. Dominican Republic - Central America - United States Free Trade Agreement (CAFTA-DR)	67. Korea, Republic of - Singapore	102. US - Peru
33. EC Treaty	68. Korea, Republic of - US	103. US - Singapore
34. EFTA - Central America (Costa Rica and Panama)	69. Korea-Australia	
35. EFTA - Chile	70. Malaysia - Australia	

Source: **Correspondence with Jose-Antonio Monteiro, Research Economist,Economic Research and Statistics Division,World Trade Organization (WTO) and https://rtais.wto.org76. See for instance Sugathan, 2016.**

Annex 3 – Additional trade flow analysis tables

As there is no established convention for the designation of "developed" and "developing" countries or areas in the United Nations system, the report groups countries by geographic region according to the UN M49 classification[77] (UNSD, 2000). Developed economies are countries commonly recognized as in United Nations statistics and reports. The term 'Least Developed Economy' includes countries commonly recognized as such in United Nations classification. The 'Transition economy' is not distinguished from the broadly defined developing countries as a single group.

To ensure meaningful cross-country comparisons, a standardization procedure is applied to the dataset. Figures in this chapter are in current United States Dollars (USD), except where otherwise specified.

Unless otherwise specified, the terms 'trade/trade flow in EST-EGs' and 'trade/trade flow in selected EST-EGs', are defined as trade in EST-EGs identified in Category 1, and Category 2, respectively. The description of 'trade/trade flow in EST-ESs' stands for trade in services of ESTs.

Footnotes

77. The OECD also follows UN M49 in common practice.

Table A3.1: Total trade, imports and exports of EST-ESs, 2016 (USD billion)

Rank	HS-6 Code	End-Use	Total
		Imported	
1	854140	PV module, wafers, cells	50.4
2	848180	Taps, cocks, valves & similar appliances	46.1
3	850440	Static converters	44.8
4	901380	Optical instruments (solar heliostats)	44.6
5	847989	Machines and mechanical appliances	35.0
6	854370	Ozone generators for water purification	31.1
7	841199	Parts of gas turbines	20.0
8	842139	Filtering or purifying machinery and apparatus for gases	18.5
9	841480	Industrial hoods, aerators, blowers and diffusers	17.8
10	940540	Solar powered lamps and fittings	16.2
		Exported	
1	901380	Optical instruments and then mention solar heliostats in brackets	48.9
2	848180	Taps, cocks, valves & similar appliances	45.8
3	854140	PV module, wafers, cells	45.2
4	850440	Static converters	43.5
5	847989	Machines and mechanical appliances	33.5
6	854370	Ozone generators for water purification	25.0
7	940540	Solar powered lamps and fittings	24.6
8	841199	Parts of gas turbines	20.8
9	842139	Filtering or purifying machinery and apparatus for gases	19.1
10	841480	Industrial hoods, aerators, blowers and diffusers	19.0
		Traded	
1	854140	PV module, wafers, cells	95.6
2	901380	Optical instruments and then mention solar heliostats in brackets	93.5
3	848180	Taps, cocks, valves & similar appliances	91.9
4	850440	Static converters	88.3
5	847989	Machines and mechanical appliances	68.5
6	854370	Ozone generators for water purification	56.1
7	841199	Parts of gas turbines	40.9
8	940540	Solar powered lamps and fittings	40.8
9	842139	Filtering or purifying machinery and apparatus for gases	37.6
10	841480	Industrial hoods, aerators, blowers and diffusers	36.8

Table A3.2: Top-5 EST-EGs imported and exported by top-3 developed countries over 2006-2016 (USD billion)

Rank	HS-6 Code	End-use	Category	Total Imports	HS-6 Code	End-use	Category	Total exports
USA (Rank 1)								
1	850440	Static converters	RE	83.6	841199	Parts of gas turbines	RE	56.2
2	848180	Taps and valves for the delivery of clean drinking water	WMWT	73.4	848180	Taps and valves for the delivery of clean drinking water	WMWT	52.4
3	854140	PV module, wafers, cells	RE	60.1	382490	Biodiesel	EPPs	40.8
4	854370	Ozone generators for water purification	WMWT	51.3	847989	Machines and mechanical appliances	SHWM	40.2
5	847989	Machines and mechanical appliances	SHWM	31.2	850440	Static converters	RE	36.3
Germany (Rank 2)								
1	854140	PV module, wafers, cells	RE	75.7	847989	Machines and mechanical appliances	SHWM	72.4
2	850440	Static converters	RE	32.1	848180	Taps and valves for the delivery of clean drinking water	WMWT	61.4
3	382490	Biodiesel	EPPs	31.3	382490	Biodiesel	EPPs	54.4
4	848180	Taps and valves for the delivery of clean drinking water	WMWT	28.4	854140	PV module, wafers, cells	RE	49.5
5	842139	Filtering or purifying machinery and apparatus for gases	APC	21.8	850440	Static converters	RE	48.2
Japan (Rank 3)								
1	854140	PV module, wafers, cells	RE	39.5	847989	Machines and mechanical appliances	SHWM	63.7
2	850440	Static converters	RE	21.2	854140	PV module, wafers, cells	RE	57.6
3	854370	Ozone generators for water purification	WMWT	20.0	901380	Optical instruments and then mention solar heliostats in brackets	RE	52.3
4	901380	Optical instruments and then mention solar heliostats in brackets	RE	13.9	382490	Biodiesel	EPPs	42.3
5	382490	Biodiesel	EPPs	12.6	854370	Ozone generators for water purification	WMWT	20.6

Note: **APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment. Total value of trade is calculated as the sum of exports and imports.**

Table A3.3 Top-5 EST-EGs imported and exported by top-3 developing countries over 2006-2016 (USD billion)

Rank	HS-6 Code	End-use	Category	Total Imports	HS-6 Code	End-use	Category	Total exports
China (Rank 1)								
1	901380	Optical instruments and then mention solar heliostats in brackets	RE	465.9	901380	Optical instruments and then mention solar heliostats in brackets	RE	293.1
2	854140	PV module, wafers, cells	RE	77.7	854140	PV module, wafers, cells	RE	173.9
3	847989	Machines and mechanical appliances	SHWM	69.0	850440	Static converters	RE	148.8
4	850440	Static converters	RE	64.7	848180	Taps and valves for the delivery of clean drinking water	WMWT	83.9
5	382490	Biodiesel	EPPs	54.7	940540	Solar powered lamps and fitting	EPPs	81.3
Mexico (Rank 2)								
1	901380	Optical instruments and then mention solar heliostats in brackets	RE	35.2	848180	Taps and valves for the delivery of clean drinking water	WMWT	13.4
2	850440	Static converters	RE	17.3	854370	Ozone generators for water purification	WMWT	12.2
3	847989	Machines and mechanical appliances	SHWM	14.2	842139	Filtering or purifying machinery and apparatus for gases	APC	11.6
4	848180	Taps and valves for the delivery of clean drinking water	WMWT	12.2	940510	Chandeliers and other electric ceiling or wall light fittings	EPPs	9.6
5	854140	PV module, wafers, cells	RE	11.5	841199	Parts of gas trubines	RE	9.3
Russia (Rank 3)								
1	848180	Taps and valves for the delivery of clean drinking water	WMWT	14.1	290511	Methanol	EPPs	4.3
2	850239	Small hydro powered generating plant	RE	9.5	848180	Taps and valves for the delivery of clean drinking water	WMWT	2.3
3	847989	Machines and mechanical appliances	SHWM	9.2	841950	Heat exchange units, industrial type	RE	1.3
4	841989	Evaporators and dryers, Condensers and cooling towers. Biogas reactors; digestion tanks; biogas refinement equipment.	APC	9.1	841370	Centrifugal pumps lined to prevent corrosion;	EPPs	42.3
5	841370	Centrifugal pumps lined to prevent corrosion;	centrifugal sewage pumps	SHWM	1.1	Ozone generators for water purification	WMWT	20.6

Note: APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment. Total value of trade is calculated as the sum of exports and imports.

Source: author calculations based on Comtrade data

Table A3.4 Top-5 EST-EGs imported and exported by top-3 LDCs over 2006-2016 (USD million)

Rank	HS-6 Code	End-use	Category	Total Imports	HS-6 Code	End-use	Category	Total exports
Ethiopia (Rank 1)								
1	730820	Wind turbine towers and masts	RE	0.88	850440	Static converters	RE	24.8
2	850300	Parts for generators used to produce electricity from renewable energy sources	RE	0.46	850300	Parts for generators used to produce electricity from renewable energy sources	RE	13.1
3	850680	Fuel cells	EPPs	0.38	842940	Tamping machines and road rollers,self-propelled	SHWM	6.1
4	847420	Crushing or grinding machines	SHWM	0.34	847989	Machines and mechanical appliances	SHWM	5.6
5	841090	For hydropower energy generation	RE	0.27	847420	Crushing or grinding machines	SHWM	4.2
Tanzania (Rank 2)								
1	730820	Wind turbine towers and masts	RE	0.21	560729	Twine, cordage, ropes and cables	EPPs	312.7
2	850440	Static converters	RE	0.16	530310	Jute and other textile bast fibers	EPPs	143.9
3	850239	Small hydro powered generating plant	RE	0.16	850421	Wet type distribution transformers	RE	76.9
4	841182	Gas turbines of a power exceeding 5,000 kW	RE	0.15	847989	Machines and mechanical appliances	SHWM	48.0
5	847989	Machines and mechanical appliances	SHWM	0.15	530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	39.7
Mozambique (Rank 3)								
1	847989	Machines and mechanical appliances	SHWM	0.18	847989	Machines and mechanical appliances	SHWM	34.8
2	847420	Crushing or grinding machines	SHWM	0.11	530390	Jute and other textile bast fibers	EPPs	13.3
3	848180	Taps and valves for the delivery of clean drinking water	WMWT	0.10	847990	Parts of machines and mechanical appliances	SHWM	11.0
4	730820	Wind turbine towers and masts	RE	0.08	842940	Tamping machines and road rollers, self-propelled	SHWM	7.0
5	850239	Small hydro powered generating plant	RE	0.08	841440	Air compressors mounted on a wheeled chassis for towing	APC	5.7

Note: **APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment. Total value of trade is calculated as the sum of exports and imports.**

Source: **author calculations based on Comtrade data**

Table A3.5 Imports and exports of top-5 selected EST-EGs for top-3 developed countries between 2006 and 2016 (USD billion)

Rank	HS-6 Code	End-use	Category	Total Imports	HS-6 Code	End-use	Category	Total exports
Germany (Rank 1)								
1	854140	PV module, wafers, cells	RE	75.7	854140	PV module, wafers, cells	RE	49.5
2	842139	Filtering or purifying machinery and apparatus for gases	APC	21.8	842139	Filtering or purifying machinery and apparatus for gases	APC	35.2
3	850300	Parts for electricity generators	RE	20.9	850300	Parts for electricity generators	RE	25.6
4	850231	Electricity generation from a renewable resource (wind).	RE	5.3	850231	Electricity generation from a renewable resource (wind).	RE	20.1
5	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	4.4	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	16.9
USA (Rank 2)								
1	854140	PV module, wafers, cells	RE	60.1	854140	PV module, wafers, cells	RE	26.2
2	842139	Filtering or purifying machinery and apparatus for gases	RE	26.6	842139	Filtering or purifying machinery and apparatus for gases	APC	22.0
3	850300	Parts for electricity generators	RE	19.6	850300	Parts for electricity generators	RE	18.1
4	850231	Electricity generation from a renewable resource (wind).	RE	12.7	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	12.1
5	842121	Filtering or purifying machinery and apparatus for water	WMWT	9.4	842121	Filtering or purifying machinery and apparatus for water	WMWT	11.9
Japan (Rank 3)								
1	854140	PV module, wafers, cells	RE	39.5	854140	PV module, wafers, cells	RE	57.6
2	850300	Parts for electricity generators	RE	5.2	850300	Parts for electricity generators	RE	12.6
3	842139	Filtering or purifying machinery and apparatus for gases	APC	4.9	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	6.5
4	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	1.8	842139	Filtering or purifying machinery and apparatus for gases	APC	5.4
5	842121	Waste incinerators or other (heat) waste	RE	0.08	841440	Air compressors mounted on a wheeled chassis for towing	APC	5.7

Note: **APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment.**

Table A3.6 Imports and exports of top-5 selected EST-EGs for top-3 developing countries between 2006 and 2016 (USD billion)

Rank	HS-6 Code	End-use	Category	Total Imports	HS-6 Code	End-use	Category	Total exports
				China (Rank 1)				
1	854140	PV module, wafers, cells	RE	77.7	854140	PV module, wafers, cells	RE	173.9
2	850300	Parts for electricity generators	RE	12.8	850300	Parts for electricity generators	RE	31.3
3	842139	Filtering or purifying machinery and apparatus for gases	APC	9.4	842139	Filtering or purifying machinery and apparatus for gases	APC	10.1
4	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	7.8	730820	Wind turbine towers and masts	RE	4.6
5	851410	Waste incinerators or other (heat) waste treatment apparatus	WMWT	7.3	842121	Filtering or purifying machinery and apparatus for water	WMWT	4.3
				Mexico (Rank 2)				
1	854140	PV module, wafers, cells	RE	11.5	842139	Filtering or purifying machinery and apparatus for gases	APC	11.6
2	850300	Parts for electricity generators	RE	8.7	854140	PV module, wafers, cells	RE	7.1
3	842139	Filtering or purifying machinery and apparatus for gases	APC	8.1	850300	Parts for electricity generators	RE	4.4
4	850231	Electricity generation from a renewable resource (wind).	RE	3.2	841919	Heaters; instantaneous or storage water heaters, non-electric	RE	3.5
5	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	2.6	842121	Filtering or purifying machinery and apparatus for water	WMWT	1.2
				Malaysia (Rank 3)				
1	854140	PV module, wafers, cells	RE	6.4	854140	PV module, wafers, cells	RE	26.40
2	850300	Parts for electricity generators	RE	2.8	842139	Filtering or purifying machinery and apparatus for gases	APC	0.96
3	842121	Filtering or purifying machinery and apparatus for water	WMWT	1.3	842121	Filtering or purifying machinery and apparatus for water	WMWT	0.51
4	851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	1.2	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	0.40
5	842139	Filtering or purifying machinery and apparatus for gases	APC	1.1	850300	Parts for electricity generators	RE	0.30

Note: **APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment.**

Source: **author calculations based on Comtrade data.**

Table A3.7 Imports and exports of top-5 selected EST-EGs for top-3 least developed countries between 2006 and 2016 (USD million)

Rank	HS-6 Code	End-use	Category	Total Imports	HS-6 Code	End-use	Category	Total exports
				Ethiopia (Rank 1)				
1	730820	Wind turbine towers and masts	RE	0.88	850300	Parts for electricity generators	RE	13.06
2	850300	Parts for electricity generators	RE	0.46	850231	Electricity generation from a renewable resource (wind).	RE	2.18
3	841090	For hydropower energy generation	RE	0.27	841090	For hydropower energy generation	RE	0.96
4	850231	Electricity generation from a renewable resource (wind).	RE	0.21	730820	Wind turbine towers and masts	RE	0.81
5	842121	Filtering or purifying machinery and apparatus for water	WMWT	0.14	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	0.59
				Tanzania (Rank 2)				
1	730820	Wind turbine towers and masts	RE	0.21	730820	Wind turbine towers and masts	RE	1.99
2	854140	PV module, wafers, cells	RE	0.09	850300	Parts for electricity generators	RE	1.82
3	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	0.07	842121	Filtering or purifying machinery and apparatus for water	WMWT	0.73
4	842121	Filtering or purifying machinery and apparatus for water	WMWT	0.07	842139	Filtering or purifying machinery and apparatus for gases	APC	0.71
5	850300	Parts for electricity generators	RE	0.06	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	0.61
				Uganda (Rank 3)				
1	854140	PV module, wafers, cells	RE	0.15	842129	Filtering or purifying machinery and apparatus for liquids	WMWT	2.34
2	730820	Wind turbine towers and masts	RE	0.13	850300	Parts for electricity generators	RE	2.20
3	841090	For hydropower energy generation	RE	0.10	842121	Filtering or purifying machinery and apparatus for water	WMWT	0.96
4	842121	Filtering or purifying machinery and apparatus for water	WMWT	0.05	842139	Filtering or purifying machinery and apparatus for gases	APC	0.41
5	850300	Parts for electricity generators	RE	0.04	841919	Heaters; instantaneous or storage water heaters, non-electric	RE	0.38

Note: APC stands for Air pollution control. C/R stands for Clean up or remediation of soil and water. EPPs stands for Environmentally preferable products. RE stands for Renewable energy. SHWM stands for Solid and hazardous waste management. WMWT stands for Wastewater management and water treatment.

Annex 4 – Revealed comparative advantage analysis

The RCA index is unbounded from above, though values exceeding one indicate that the country concerned possesses a competitive advantage in exporting the particular product, based on existing trade patterns. This said, the RCA index values are mostly indicative and cannot be used for causal inferences. Moreover, the values reported in Table A4.1 and Table A4.2 have been calculated on the basis of gross, as opposed to value-added, trade. Nonetheless, for purposes of exposition, RCA index values in excess of 1.0 are coded red in Table A4.1, Table A4.2 and indicate the country-product combinations with potential for benefitting from tariff and non-tariff liberalization of EST-EGs.

Table A4.1 indicates that all developed country exporters in our sample, except New Zealand, exhibit an RCA in exporting one or more of the top-10 exported EST-EGs with a clearer environmental end-use. Germany, in particular, shows an RCA index value in excess of one for nine of the top-10 exported EST-EGs in both 2006 and 2016. An RCA value exceeding unity across more products in 2016 compared to 2006 is observed for only three countries (Republic of Korea, Singapore and US); the opposite holds true for four countries (Australia, Japan, Poland and Switzerland). Moreover, nine of the top-10 exported EST-EGs – barring HS854140 - show a large number of developed country exporters exhibiting an RCA in exporting. These countries and products are therefore likely to benefit more from tariff and non-tariff liberalization of EST-EGs, based on existing trade patterns.

Table A4.1 RCA indices for top developed country exporters across the top-10 selected EST-EGs exports (2006 and 2016)

Country	Year	730820	841790	841919	842121	842129	842139	850231	850300	851410	854140
Australia	2006	0.25	0.45		1.15	0.44	0.08	1.90	0.08	0.04	0.41
Australia	2016	0.11	0.18	0.03	0.47	0.12	0.09	0.02	0.08	0.03	0.03
Canada	2006	0.54	1.01	0.19	2.09	0.63	1.26	0.01	0.49	0.15	0.10
Canada	2016	1.87	1.54	0.05	1.68	0.38	0.63	0.05	0.38	0.26	0.15
Denmark	2006	7.76	0.94	2.21	2.00	1.56	1.10	49.44	13.57	0.98	0.16
Denmark	2016	18.77	0.84	2.55	2.23	1.83	0.88	65.38	2.42	1.06	0.09
France	2006	0.52	2.09	2.39	1.16	3.37	0.74	0.03	0.89	0.72	0.29
France	2016	0.11	1.56	2.20	1.03	2.68	0.77	0.14	0.81	0.81	0.23
Germany	2006	0.30	1.57	2.01	1.97	2.70	1.86	2.58	1.13	1.98	1.17
Germany	2016	1.22	1.63	1.28	1.71	2.53	2.48	3.23	1.10	2.21	0.62
Italy	2006	0.61	3.87	0.76	1.63	1.45	1.03	1.33	1.46	2.46	0.17
Italy	2016	0.77	4.81	1.66	2.03	1.21	1.09	0.01	1.86	3.82	0.24
Japan	2006	0.02	1.09	0.05	0.58	1.65	0.55	0.77	1.23	3.08	4.77
Japan	2016	0.01	0.72	0.02	0.44	1.96	0.48	0.00	1.43	3.01	1.82
Korea	2006	0.29	0.57	0.04	0.44	0.35	0.25	0.00	0.62	0.61	0.77
Korea	2016	0.22	0.48	0.06	2.11	0.39	0.61	0.00	0.67	1.33	2.52
Netherlands	2006	0.29	0.57	0.71	1.10	0.54	0.66	0.03	0.22	2.61	0.40
Netherlands	2016	0.18	0.24	0.94	1.27	0.80	0.45	0.37	0.44	0.12	0.55

Table A4.1 RCA indices for top developed country exporters across the top-10 selected EST-EGs exports (2006 and 2016) (continued)

New Zealand	2006	0.03	0.06	0.62	0.44	0.16	0.07	0.02	0.16	0.00	0.01
New Zealand	2016		0.05	0.01	0.20	0.14	0.08	0.11	0.04	0.04	0.02
Poland	2006	2.66	0.67	5.13	0.67	0.38	1.04	0.01	1.31	1.05	0.04
Poland	2016	0.32	0.86	3.95	0.71	0.45	1.50	0.04	1.19	1.12	0.20
Singapore	2006	0.05	0.12	0.03	0.59	0.35	0.12	0.03	0.89	0.01	0.97
Singapore	2016	0.05	0.35	0.04	0.48	0.80	0.19	0.00	0.48	0.18	2.31
Slovak Re-public	2006	6.91	0.19	1.23	0.56	0.22	0.18		1.93	0.18	0.02
Slovak Re-public	2016	1.98	0.10	1.96	0.21	0.43	1.05		1.01	0.01	0.12
Spain	2006	1.14	1.74	0.53	1.33	0.55	0.41	5.33	1.21	0.37	0.72
Spain	2016	3.91	2.41	0.85	1.43	0.23	0.23	7.98	2.30	0.48	0.07
Switzerland	2006	0.07	0.41	1.50	1.51	0.91	0.42	0.00	1.23	2.70	0.25
Switzerland	2016	0.01	0.20	0.63	0.60	0.27	0.36	0.00	0.87	1.25	0.06
UK	2006	0.26	0.47	0.83	0.93	1.02	1.27	0.03	1.06	0.61	0.69
UK	2016	0.14	0.95	0.46	1.08	2.39	2.36	0.03	0.54	0.47	0.12
USA	2006	0.82	0.67	0.70	2.38	1.97	1.44	0.31	1.52	1.57	0.83
USA	2016	0.18	1.12	1.18	1.74	2.07	1.43	0.03	0.82	1.24	0.34

Source: **author calculations based on Comtrade data**

Table A4.2 indicates that all developing country exporters in our sample, except Russia, exhibit an RCA in exporting one or more of the top-10 exported EST-EGs with a clearer environmental end-use. China, in particular, shows an RCA index value in excess of one for four of the top-10 exported EST-EGs in 2016. An RCA value exceeding unity across more products in 2016 compared to 2006 is observed for only two countries (China and Viet Nam); the opposite holds true for four countries (Malaysia, Mexico, South Africa and Thailand). Moreover, two of the top-10 exported EST-EGs – HS 730820 and HS 854140 - show a greater number of developing country exporters exhibiting an RCA in exporting. These countries and products are therefore likely to benefit more from tariff and non-tariff liberalization of EST-EGs, based on existing trade patterns

Table A4.2: RCA indices for top developing country exporters across the top-10 selected EST-EGs exports (2006 and 2016)

Country	Year	730820	841790	841919	842121	842129	842139	850231	850300	851410	854140
Brazil	2006	1.03	0.77	0.04	0.39	0.71	0.28	0.01	2.10	0.13	0.01
Brazil	2016	0.87	0.27	0.04	0.48	0.41	0.82	0.01	2.04	0.10	0.00
China	2006	1.49	1.16	0.29	0.27	0.13	0.28	0.01	0.85	0.54	1.51
China	2016	1.40	1.02	0.65	0.65	0.55	0.70	0.55	1.71	0.91	2.38
India	2006	7.53	0.45	0.37	0.47	0.12	0.09	5.73	0.94	0.15	0.66
India	2016	4.57	1.08	0.75	0.87	0.36	0.29	0.06	0.81	0.21	0.15
Indonesia	2016	3.68	0.00	0.01	0.05	0.03	0.03	0.00	0.15	0.02	0.06
Malaysia	2006	1.76	0.09	0.07	0.36	0.14	0.23	0.02	0.18	0.07	3.71
Malaysia	2016	0.12	0.10	0.05	0.77	0.41	0.84	0.00	0.15	0.10	6.94
Mexico	2006	0.35	0.11	8.91	0.52	0.46	2.30	0.00	1.01	0.01	0.52
Mexico	2016	0.18	0.31	9.01	0.89	0.81	2.92	0.00	0.99	0.11	0.75
Philippines	2016	0.02	0.02	0.00	0.10	0.01	0.00		0.96		7.02
Russia	2006	0.17	0.20	0.01	0.16	0.09	0.05	0.00	0.11	0.14	0.03
Russia	2016	0.32	0.06	0.11	0.29	0.09	0.11	0.00	0.17	0.13	0.02
South Africa	2006	15.83	0.25	0.12	0.59	0.28	49.08	0.01	0.55	0.02	1.12
South Africa	2016	1.31	0.47	0.30	0.51	0.39	15.73	0.00	0.11	0.05	0.40
Thailand	2006	1.79	0.08	0.06	0.25	0.14	0.66	0.00	0.94	0.01	1.29
Thailand	2016	0.10	0.05	0.11	0.11	0.22	0.48	0.00	0.36	0.11	1.38
Turkey	2006	17.16	0.99	0.63	0.61	0.23	0.23	0.00	0.73	0.31	0.06
Turkey	2016	5.53	0.90	0.82	0.85	0.34	0.35	0.02	0.70	0.80	0.02
Viet Nam	2006	0.11	0.00	0.00	0.02	0.00	0.12	6.86	0.39	0.00	0.08
Viet Nam	2016	3.46	0.05	0.00	0.03	0.04	0.01	0.22	0.17	0.00	2.75

Source: author calculations based on Comtrade data

Table A4.3 indicates that only three LDC exporters - New Caledonia, Niger and Senegal - exhibit an RCA in exporting one product each – HS 841919, HS 842121 and HS 850300 - of the top-10 exported selected EST-EGs with a clearer environmental end-use. This suggests that the majority of LDC exporters have a comparative disadvantage in exporting most of these products, which points to their limited potential for benefitting from EST liberalization, based on existing export patterns.

Table A4.3 RCA indices for top LDC exporters across the top-10 selected EST-EG exports (2006 and 2016)

Country	Year	730820	841790	841919	842121	842129	842139	850231	850300	851410	854140
Benin	2006					0.00			0.01		
Benin	2016	0.39		0.25							
Burkina Faso	2016				0.02	0.00	0.00		0.02		0.05
Ethiopia	2006										
Ethiopia	2016			0.00	0.01	0.00	0.00				0.00
Guinea	2006								0.04	0.00	
Madagascar	2006					0.01	0.00		0.00		
Madagascar	2016	0.01			0.01	0.05	0.00		0.00		0.00
Malawi	2006		0.00		0.00	0.00			0.10		0.00
Mali	2006				0.02	0.00			0.01	0.01	
Mali	2016					0.02	0.01		0.01		0.00
Mozambique	2006	0.00	0.09	0.18	0.04	0.00	0.01		0.01		
Mozambique	2016		0.00	0.00	0.00	0.01	0.04		0.14		0.00
Nepal	2016	0.03			0.00						
New Caledonia	2006			29.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Niger	2006		0.00	0.01			0.00				
Niger	2016	0.43				0.01			1.16		
Rwanda	2006								0.04		
Rwanda	2016	0.04		0.77	0.05	0.00	0.00		0.03		0.02
Senegal	2006	0.33			0.02	0.03	0.01		0.01		0.00
Senegal	2016	0.09	0.04	0.01	1.83	0.04	0.02		0.30		0.01
Tanzania	2006	0.00	0.00	0.01	0.01	0.00	0.00		0.02		
Tanzania	2016	0.85		0.00	0.00	0.00	0.00		0.00		0.01
Togo	2016										
Uganda	2006		0.03	0.03	0.02	0.01	0.00		0.04		0.01
Uganda	2016			0.00	0.11	0.03	0.00		0.00		0.05
Zimbabwe	2006				0.00	0.00	0.00	0.00	0.00		
Zimbabwe	2016			0.02	0.00	0.00	0.00		0.00	0.01	0.00

Source: author calculations based on Comtrade data

Annex 5 – Intra-industry trade analysis

Table A5.1, A5.2 and A5.3 report the Grubel-Lloyd (1975) indices[78] of intra-industry trade (IIT) for the top developed, developing and LDC trading countries, respectively, in the top-10 traded EST-EGs with a clearer environmental end-use, at two points in time - 2006 and 2016 - subject to data availability. Consistent with the aggregate analysis in the rest of this report, these indices have been calculated for each country/product pair with respect to the ROW as opposed to bilaterally. The value of the IIT index ranges from zero (no IIT) to one (full IIT), with larger values indicating significant two-way trade in the same HS 6-product, suggestive of value-chain-type trade (for instance see the Sussex Framework).

For purposes of exposition, IIT index values in excess of 0.5 are coded red.

Table A5.1: IIT indices for top developed country traders across the top-10 traded EST-EGs with clearer environmental end-use (2006 and 2016)

Country	Year	730820	841790	841919	842121	842129	842139	850231	850300	851410	854140
Australia	2006	0.37	0.93	-	0.71	0.30	0.21	0.84	0.17	0.25	0.83
Australia	2016	0.22	0.56	0.06	0.53	0.12	0.13	0.02	0.52	0.10	0.07
Canada	2006	0.47	0.63	0.38	0.74	0.85	0.82	0.01	0.52	0.46	0.44
Canada	2016	0.78	0.79	0.02	0.95	0.33	0.44	0.15	0.64	0.56	0.55
Denmark	2006	0.21	0.48	0.38	0.55	0.94	0.66	0.00	0.51	0.70	0.74
Denmark	2016	0.20	0.68	0.40	0.52	0.73	0.96	0.01	0.77	0.80	0.52
France	2006	0.65	0.51	0.76	0.83	0.44	0.81	0.05	0.99	0.92	0.86
France	2016	0.18	0.56	0.64	1.00	0.74	0.96	0.53	0.66	0.89	0.78
Germany	2006	0.96	0.41	0.85	0.30	0.42	0.81	0.87	0.94	0.45	0.71
Germany	2016	0.80	0.55	0.96	0.39	0.43	0.80	0.18	0.93	0.16	0.94
Italy	2006	0.59	0.20	0.96	0.55	0.61	0.75	0.79	0.82	0.25	0.40
Italy	2016	0.60	0.36	0.74	0.41	0.72	0.85	0.09	0.67	0.28	0.84
Japan	2006	0.10	0.63	0.37	0.84	0.51	0.86	0.76	0.68	0.11	0.38
Japan	2016	0.08	0.94	0.80	0.93	0.35	0.98	0.00	0.56	0.19	0.90
Korea	2006	0.51	0.80	0.40	0.65	0.72	0.67	0.01	0.97	0.29	0.60
Korea	2016	0.08	0.95	0.92	0.48	0.74	0.94	0.02	0.93	0.87	0.75
Netherlands	2006	0.75	0.63	0.24	0.58	0.91	0.98	0.09	0.90	0.07	0.94
Netherlands	2016	0.37	0.80	0.30	0.53	0.97	0.90	0.49	0.86	0.89	0.87
New Zealand	2006	0.27	0.95	0.93	0.38	0.16	0.19	0.00	0.24	0.01	0.08
New Zealand	2016	-	0.29	0.03	0.22	0.21	0.33	0.76	0.19	0.22	0.13
Poland	2006	0.19	0.70	0.40	0.84	0.61	0.76	0.22	0.69	0.65	0.39
Poland	2016	0.95	0.99	0.31	0.94	0.94	0.74	0.28	0.94	0.88	0.72
Singapore	2006	0.51	0.65	0.22	0.93	0.89	0.74	0.31	0.95	0.12	0.99
Singapore	2016	0.13	0.91	0.48	0.97	0.96	0.77	0.19	0.80	0.61	0.65
Slovak Republic	2006	0.22	0.28	0.99	0.99	0.44	0.10	-	0.93	0.43	0.20
Slovak Republic	2016	0.21	0.34	0.85	0.44	0.91	0.78	-	0.97	0.05	0.79
Spain	2006	0.76	0.48	0.54	0.86	0.54	0.30	0.15	0.81	0.51	0.41
Spain	2016	0.27	0.51	0.94	0.72	0.38	0.17	0.04	0.52	0.87	0.67
Switzerland	2006	0.30	0.80	0.86	0.76	0.83	0.70	0.03	0.85	0.89	0.84

Footnotes

78. 1-[abs(X^k_i-M^k_i)/(X^k_i+M^k_i)] where X^k_i is country i's export of product k to ROW and M^k_i is country i's import of product k from ROW.

Table A5.1: IIT indices for top developed country traders across the top-10 traded EST-EGs with clearer environmental end-use (2006 and 2016) (continued)

Switzerland	2016	0.13	0.84	0.50	0.98	0.40	0.99	0.06	0.91	0.92	0.41
UK	2006	0.64	0.61	0.90	0.98	0.66	0.88	0.04	0.82	0.92	0.93
UK	2016	0.10	0.53	0.48	0.92	0.50	0.71	0.04	0.53	0.83	0.27
USA	2006	0.46	0.98	0.41	0.77	0.87	0.84	0.12	0.97	0.88	0.83
USA	2016	0.15	0.95	0.58	0.95	0.83	0.88	0.23	0.64	0.97	0.23

Source: author calculations based on Comtrade data

Table A5.2: IIT indices for top developing country traders across the top-10 traded EST-EGs with clearer environmental end-use (2006 and 2016)

Country	Year	730820	841790	841919	842121	842129	842139	850231	850300	851410	854140
Brazil	2006	-	0.83	0.99	0.89	0.60	0.78	0.02	0.44	0.24	0.02
Brazil	2016	0.06	0.30	0.37	0.57	0.48	0.91	0.05	0.83	0.36	0.01
China	2006	0.00	0.81	0.04	0.76	0.19	0.54	0.02	0.90	0.24	0.96
China	2016	0.00	0.49	0.03	0.72	0.91	0.62	0.01	0.33	0.53	0.71
India	2006	0.06	0.33	0.40	0.32	0.30	0.29	0.05	0.46	0.99	0.88
India	2016	0.09	0.87	0.37	0.90	0.64	0.73	0.93	0.52	0.54	0.08
Indonesia	2016	0.38	0.00	0.30	0.06	0.02	0.06	0.29	0.26	0.06	0.36
Malaysia	2006	0.66	0.31	0.54	0.52	0.22	0.55	0.71	0.47	0.23	0.37
Malaysia	2016	0.45	0.05	0.24	0.54	0.70	0.73	0.37	0.16	0.18	0.33
Mexico	2006	0.55	0.39	0.12	0.56	0.34	0.80	0.00	0.59	0.01	0.69
Mexico	2016	0.19	0.66	0.24	0.89	0.76	0.83	0.00	0.63	0.13	0.75
Philippines	2016	0.02	0.03	0.01	0.11	0.03	0.01	-	0.77	-	0.28
Russia	2006	0.31	0.53	0.03	0.16	0.10	0.11	0.23	0.96	0.16	0.98
Russia	2016	0.14	0.30	0.15	0.28	0.13	0.27	0.01	0.87	0.09	0.22
South Africa	2006	0.05	0.25	0.97	0.56	0.47	0.06	0.81	0.77	0.04	0.91
South Africa	2016	0.37	0.85	0.70	0.55	0.65	0.12	0.00	0.18	0.15	0.68
Thailand	2006	0.33	0.50	0.13	0.48	0.30	0.74	0.20	0.98	0.01	0.72
Thailand	2016	0.17	0.11	0.86	0.36	0.52	0.86	0.01	0.46	0.40	0.87
Turkey	2006	0.01	0.91	0.70	0.48	0.15	0.22	0.00	0.83	0.43	0.49
Turkey	2016	0.09	0.64	0.29	0.98	0.32	0.25	0.00	0.95	0.70	0.01
Viet Nam	2006	0.45	0.00	0.01	0.04	0.01	0.35	0.00	0.69	0.00	0.47
Viet Nam	2016	0.08	0.02	0.01	0.05	0.11	0.03	0.03	0.32	0.00	0.56

Source: author calculations based on Comtrade data

Table A5.3: IIT indices for top LDC traders across the top-10 traded EST-EGs with clearer environmental end-use (2006 and 2016)

Country	Year	730820	841790	841919	842121	842129	842139	850231	850300	851410	854140
Benin	2006	-	-	-	-	0.02	-		0.03	-	-
Benin	2016	0.07	-	0.66	-	-	-	-	-	-	-
Burkina Faso	2016	-	-	-	0.02	0.00	0.00		0.07	-	0.02
Ethiopia	2006	-	-	-	-	-	-	-	-	-	-
Ethiopia	2016	-	-	0.00	0.00	0.00	0.00	-	-	-	0.00
Guinea	2006	-	-	-	-	-	-	-	0.01	0.09	-
Madagascar	2006	-	-	-	-	0.01	0.00	-	0.03	-	-
Madagascar	2016	0.01	-	-	0.02	0.09	0.01	-	0.00	-	0.00
Malawi	2006	-	0.01	-	0.00	0.00	-	-	0.42	-	0.00
Mali	2006	-	-	-	0.07	0.01	-		0.03	-	-
Mali	2016	-	-	-	-	0.04	0.08	-	0.03	-	0.00
Mozambique	2006	0.00	0.90	0.74	0.10	0.01	0.06		0.04	-	-
Mozambique	2016	-	0.01	0.01	0.00	0.01	0.07	-	0.02	-	0.01
Nepal	2016	0.00	-	-	0.00	-	-	-	-	-	-
New Caledonia	2006	-	-	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.01
Niger	2006	-	0.02	0.08	-	-	0.02		-	-	-
Niger	2016	0.06	-	-	-	0.02	-		0.50	-	-
Rwanda	2006	-	-	-	-	-	-	-	0.02	-	-
Rwanda	2016	0.00	-	0.18	0.00	0.00	0.00	-	0.07	-	0.01
Senegal	2006	0.01	-	-	0.00	0.01	0.01	-	0.00	-	0.00
Senegal	2016	0.03	0.06	0.03	0.82	0.04	0.14		0.15	-	0.01
Tanzania	2006	0.00	0.00	0.00	0.00	0.00	0.00	-	0.03	-	-
Tanzania	2016	0.11	-	0.00	0.00	0.00	0.00	-	0.01	-	0.02
Togo	2016	-	-	-	-	-	-		-	-	-
Uganda	2006	-	0.04	0.03	0.01	0.01	0.02	-	0.04	-	0.01
Uganda	2016	-	-	0.00	0.12	0.08	0.00	-	0.01	-	0.03
Zimbabwe	2006	-	-	-	0.00	0.03	0.00	0.68	0.03	-	-
Zimbabwe	2016	-	-	0.00	0.00	0.01	0.00	-	0.01	0.17	0.00

Source: author calculations based on Comtrade data

Annex 6 – Methodology of literature review

The review has been carried out between June and August 2018 using a systematic coding procedure presented in Table A6.1. Overall, with two exceptions, all sources were published after 2001. 38 and 56 sources rely on quantitative and qualitative data respectively, while 32 adopt a mix-methods approach. Of the quantitative studies, 33 use econometric analysis modelling the impact of trade liberalization mostly using the WTO and APEC lists, as well as a combination of the two and other lists presented in Table 1.1. 35 studies are country- or region-specific (8 in Africa, 5 in South America, 11 in Asia, and 11 in the US and Europe). Most agency-commissioned reports and articles are from UN Environment and other UN agencies (23), the International Centre for Trade and Sustainable Development (ICTSD) (10), the International Institute for Sustainable Development (IISD) (4), OECD (5), and the ITC (2). In terms of their themes, 62 studies deal directly with the impact of ESTs trade liberalization on countries' economies and environment (of which 5 focus specifically on ES), 14 look at the role of green industrial policy, 22 focus on the trade-off between economic growth and environmental protection, 18 address the benefits of specific environmental goods and ESTs, while the remaining 4 consider the effectiveness of payments for ecosystem services and other finance instruments in dealing with environmental externalities. Of these, 30 sources provide an assessment of the negotiation process in either the APEC or the WTO.

All 126 studies were categorized based on 8 themes summarized in Table A6.1. 18 sources look at trade liberalization (not specific to ESTs) and its environmental impact, 13 directly advocate liberalization of trade in ESTs, while 10 criticize its potential effects. According to 35 studies, liberalizing ESTs is not enough to decouple economic growth from environmental degradation and other measures such as green industrial policy, participation in global value chains, circular economies, technology transfer and measures to overcome non-tariff barriers are further required. The scope for green industrial policy is specifically discussed by 24 studies, while 15 are concerned with the benefits and challenges of the negotiations on the liberalization of ESTs within the WTO and APEC. The remaining sources span 10 case studies on the impact of liberalized markets for environmental goods, and 3 reports on the challenges associated with the phasing out of subsidies on fossil fuels.

Finally, of 80 articles addressing the impact of ESTs trade liberalization, 28 are openly in favour and only 4 strictly against it, while 49 address liberalization from a critical perspective suggesting that it benefits only restricted groups (i.e. developed countries) and/or further require element of green industrial policy to address aspects such as non-tariff barriers, technology transfer, EPPs, property rights, and other industrialization and welfare-related dynamics (see Figure A6.1).[79]

Footnotes

79. Note that, as part of Chapter 4, on top of the 126 sources coded in Table A6.1, a number of sources have been partially consulted and are further referenced in the following sections. Whilst only marginally connected to trade in ESTs, they play an important role in informing the discussion.

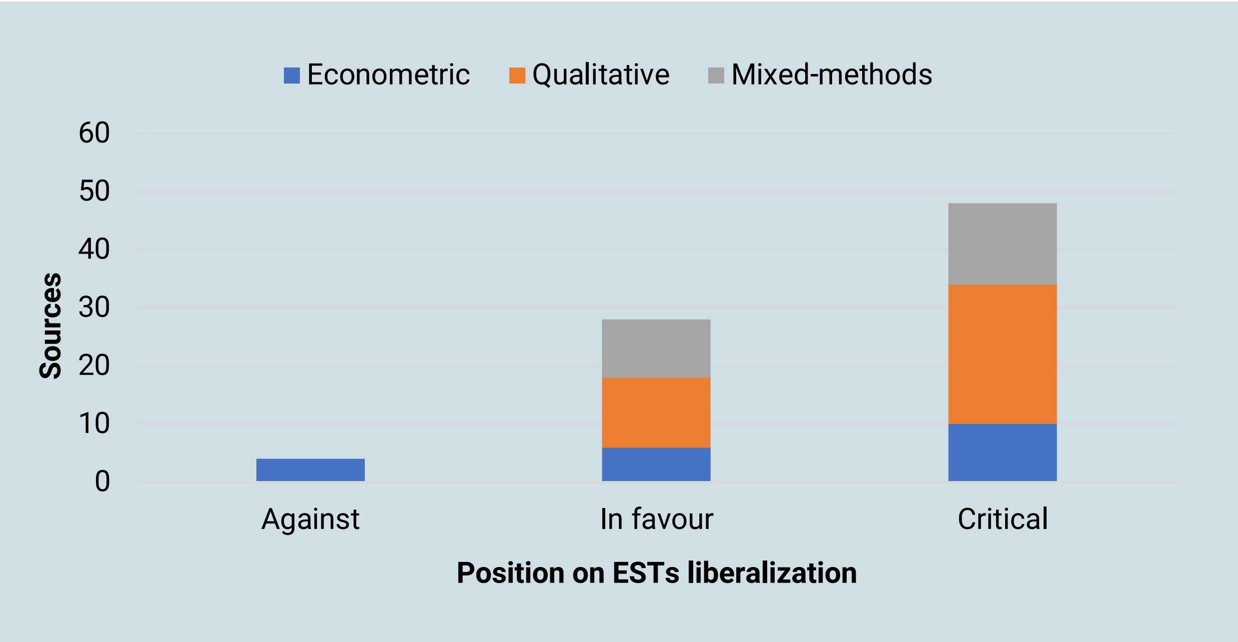
Table A6.1 Themes and sub-themes

Theme	Content	Sources
Trade liberalization and the environment (not specific to ESTs)	Kuznets Curve (scale, composition, and technique effect)	(Antweiler, Copeland, and Taylor, 2001; Jackson, 2016; Kagohashi, Tsurumi, and Managi, 2015; Lovely and Popp, 2011; Managi, Hibiki, and Tsurumi, 2009; Nimubona, 2012; D. I. Stern, 2014)
	Testing the Pollution Haven Hypothesis	(Batrakova, 2012; Cole, 2004; Cole, Elliott, & Zhang, 2017; Frankel and Rose, 2005; Grossman and Krueger, 1991)
	Impact of technology transfer	(Anyangah, 2010; Chataway, Hanlin, and Kaplinsky, 2014)
	Trade-off between social welfare and environment protection	(Catlin, Phipps, and Luchs, 2014; Millennium Ecosystem Assessment, 2005; Roberts and Thanos, 2003; UNEP, 2011)
Calling for the liberalization of ESTs	Benefits of liberalisation: lowering prices, favouring returns to scale and technology transfer	(Frey, 2016; Ikiara and Mutua, 2004; KOMMERS, 2014a; Manyuchi, 2017; Mathur, 2014; Matsumura, 2016; Sauvage and Timiliotis, 2017; UNEP, 2011, 2013, 2014; WTO and UNEP, 2009; Yoo and Kim, 2011; Znamenackova, Sauer, Fernando, and Cervantes, 2014)
Criticizing certain effects of liberalization of ESTs	Benefits are restricted to developed countries	(De Alwis, 2015; Howse and Van Bork, 2006; Gary Clyde Hufbauer, Charnovitz, and Kim, 2009; Gary Clyde Hufbauer and Kim, 2010; Mytelka, 2007; Tamini and Sorgho, 2016; Timbur, 2012)
	Liberalisation slows down industrialisation of developing countries	(Dijkstra and Mathew, 2016; Mathew and de Córdoba, 2009; Rodrik, 2014)
Liberalization of ESTs is not enough	Non-tariff barriers need to be addressed	(Baltzer and Jensen, 2015; Copeland and Taylor, 2004; Cosbey, 2008; Damania, Fredriksson, and List, 2003; Hammeren, 2014; He, Fang, Wang, and Peng, 2015; Iturregui and Dutschke, 2005; Kalirajan, 2012; Li et al., 2013; Monkelbaan, 2013; Vikhlyaev, 2011; Wooders, 2009)
	Green industrial policy measures are further required	(Acemoglu, Aghion, Bursztyn, and Hemous, 2012; Altenburg and Rodrik, 2017; Copeland, 2012; K. S. Gallagher, 2006; Less & McMillan, 2005; Lütkenhorst, Altenburg, Pegels, and Vidican, 2014; D. Stern and Jotzo, 2010; UNFCCC, 2016; Wan, Nakada, and Takarada, 2018; Zugravu-Soilita, 2018)
	The impact of circular economies	(EMF, 2017, 2018; Balke, Evans, Rabbiosi and Monnery 2017; Wijkman and Skånberg, 2016)
	Addressing integration into global value chains	(Bucher, H. et al., 2014; Poulsen, Ponte, and Sornn-Friese, 2018)
	Creating markets for ESTs including via domestic and regional environmental regulations	(Geloso Grosso, 2007; IFOAM, 2011; Jha, 2008; Vossenaar, 2010; Zhang, 2009, 2013)

Discussing green industrial policy	Green industrial policy, industrialisation and technology adoption	(Altenburg and Pegels, 2012; Ambec, 2017; Auktor, 2017; Correa, 2013; David, Nimubona, and Sinclair-Desagné, 2011; Balke et al., 2017; Greaker and Rosendahl, 2008; Jha, 2013; Kazmerski, 2011; Never and Kemp, 2017; Padilla, 2017; Thiruchelvam, Kumar, and Visvanathan, 2003; UNCTAD, 2018)
	Employment creation via green industrial policy	(EPIA, 2012; Esposito, Haider, Semmler, and Samaan, 2017; Fankhauser, Sehlleier, and Stern, 2008)
	The use of green industrial policy and litigations within the WTO	(Cosbey, 2017; Lewis, 2014b, 2014a; Morsink, Hofman, and Lovett, 2011; Rubini, 2012)
	Effectiveness and limitations of the payment of ecosystem services	(Engel, Pagiola, and Wunder, 2008; Jayachandran et al., 2017; Pagiola, Arcenas, and Platais, 2005)
Negotiations on the liberalization of ESTs	Need to include non-tariff barriers and EPPs	(Araya, 2016; Cosbey, 2014; Khatun, 2012; Oh, 2017; UNESCWA, 2007; Vossenaar, 2013; Wu, 2014; Yu, 2007)
	Overcoming zero-sum games and countries' mercantilist approaches	(Balineau and De Melo, 2013; Harashima, 2008; Jung, 2014)
	Addressing technical issues (e.g. dual-usage, specificity of HS subheadings, flexibility of lists)	(Cosbey, Aguilar, Ashton, and Ponte, 2010; Steenblik, 2005a; UNEP, 2015c; Vossenaar, 2016)
Challenges of phasing out of dirty tariffs	Negative impact on growth and welfare	(Cosbey, Wooders, Bridle, and Casier, 2017; Jakob, Chen, Fuss, Marxen, and Edenhofer, 2015; RCREEE, 2013)
EPPs and renewables (case studies and definitions)	Economic, social, and environmental benefits (certified agriculture and aquaculture; renewable energies)	(Bengtsson, Ahnström, and Wetbull, 2005; Ikiara and Mutua, 2004; Lazzerini et al., 2014; REN21, 2017; Tothova, 2005; UNCTAD, 1995; UNEP, 2016c, 2015a, 2015b, 2016a, 2016b; Willer and Lernoud, 2015)

Source: author's elaboration.

Figure A6.1 Reviewed sources evaluating the impact of ESTs liberalization (2001-2018)



Annex 7 – Opportunities and challenges of trade liberalization

Economic, social, and environmental opportunities of trade liberalization

Exports have been described as an "engine of growth" by a number of economists (Balassa, 1978; Krueger, 1978; Malcolm, Little, Scitovsky, and Scott, 1970; Nurske, 1961). The argument in favour of trade liberalization rests on David Ricardo's principle of comparative advantage and the Heckscher-Ohlin model of international trade. Accordingly, nations gain from trade as they specialize in the production and export of products that use their relatively abundant and cheapest factors of production.[80] Static gains are those that accrue from the reallocations of existing resources through exchange and specialization (Fu, 2004; Myint, 1958). Conversely, dynamic gains occur through *learning-by-exporting* and participation in global value chains, as vertical and horizontal market linkages enable firms' upgrading through knowledge transfer and "trade-induced innovation" (Aw, Roberts, and Xu, 2008; Fafchamps, El Haine, and Zeufack, 2007; Fu and Gong, 2011; Gereffi, Humphrey, and Sturgeon, 2005; Gereffi and Lee, 2016; Lileeva and Trefler, 2010; Melitz and Trefler, 2012; Siba and Gebreeyesus, 2017). In addition, gains from trade are generated through foreign exchange, to the extent that fluctuations in commodity prices and volatility of export earnings negatively affect economic growth (Addison, Ghoshray, and Stamatogiannis, 2016; Blattman, Hwang, and Williamson, 2007; Fu, 2004).

As a non-rival good encompassing tacit and codified knowledge aimed at improving products, processes, and organizational practices, innovation is expected to create and sustain competitive advantages, while further fostering productivity and profitability (Fu et al., 2011; Rosenbusch, Brinckmann, and Bausch, 2011). In a globalized economy where over 60% of trade takes place within global value chains (Timmer, Erumban, Los, Stehrer, and De Vries, 2014; UNCTAD, 2013), innovation increasingly depends on accessing globally dispersed knowledge and leveraging it to the benefit of local industries (Ernst and Kim, 2002; Mudambi and Venzin, 2010). In this context, a liberalized economy allows countries to reap the benefits of specialization acting as suppliers of global markets, from which they would be otherwise excluded (Cattaneo, Gereffi, Miroudot, and Taglioni, 2013; Jones, Kierzkowski, and Lurong, 2005). This is particularly the case for developing countries, where lower labour costs and abundance of natural resources attract foreign knowledge in the form of foreign direct investment and outsourced production, favouring technology transfer and human resources development (AfDB, OECD, and UNDP, 2014, p. 15; Gereffi, 1999, 2014). In such context, as liberalization fosters innovation and increased consumption via lower prices, wages are expected to increase as aggregate demand leads to greater labour demand (Milberg and Winkler, 2011).

The benefits of trade liberalization on the environment have been discussed in a number of studies with mixed results (Antweiler et al., 2001; Cole, 2004; Copeland, 2012; Copeland and Taylor, 2004). Economic growth has been associated with environmental degradation via the *scale and composition effects*. The first refers to an increase in pollution due to the overall increase in production output (Copeland and Taylor, 2004; Grossman and Krueger, 1995), whilst the second implies that as countries shift towards capital-intensive sectors, their pollution potential is likely to increase (Antweiler et al., 2001; Cole and Elliot, 2003). Nevertheless, proponents of the Environment Kuznets Curve (EKC) hypothesis argue that after an initial negative impact, increasing income levels lead to environmental improvements. The main logic is that the *scale and composition effects* are offset by a *technique effect* as income-induced demand leads to the adoption of environment

Footnotes

80. While in the Ricardian theory, the source of comparative advantage rests on technological differences across countries, the Heckscher-Ohlin model considers technology as constant across countries and the source of comparative advantage is identified in the different capital and labour endowments.

friendly technologies (Grossman and Krueger, 1991; Kagohashi et al., 2015; Selden and Song, 1994; Shafik, 1994; Suri and Chapman, 1998).[81] Moreover, an *indirect composition effect* is expected to reduce the polluting impact of capital-intensive industries as more stringent environmental regulations and standards are gradually introduced and enforced (Kagohashi et al., 2015; Zugravu-Soilita, 2018).

In this respect, Lovely and Popp (2011) argue that trade liberalization reduces countries' abatement costs by facilitating access to pollution control technologies. To the extent that, nowadays, developing countries can access off-the-shelf technologies to reduce emissions, the authors further observe how trade liberalization represents a potential channel for income growth through cleaner consumption patterns (Frankel and Rose, 2005). Similarly, other scholars have presented evidence suggesting that developing countries' levels of environmental degradation are lower than those achieved by early industrializing economies and often supported by more ambitious abetment policies (Dasgupta, Laplante, Wang, and Wheeler, 2002; D. Stern and Jotzo, 2010). Yet, as described in the next section, critics argue against the EKC hypothesis pointing to a positive association between trade liberalization and environmental degradation.

Economic, social, and environmental challenges of trade liberalization

Although protectionist measures were historically used by developed nations to promote their national industries (H.-J. Chang, 2002), it was not until the mid of the 20th century that the case for industrial policy emerged in the literature. At a time when the demand for commodities and primary products had become more and more inelastic with respect to price and income (Fu, 2004, p. 6), *structuralist* economists indicated free trade as a "source of impoverishment" causing a deterioration in the terms of trade of developing countries. In response, they further advocated for a government intervention to promote manufacturing as a source of innovation and growth (Prebisch, 1950; Singer, 1950, 1975). Within this context, scholars have argued in favour of "control mechanisms" to prevent coordination failures and support local innovation and industrialization (Amsden, 2001; H.-J. Chang, 2002, 2013; Lundvall, 2007; Sanchez-Ancochea, 2009). The main rationale informing this approach is that, as local producers are protected from more advanced foreign firms, they can achieve competitiveness through economies of scale by reducing unit costs and accumulating production experience – i.e. *learning-by-doing*.

Government intervention can take different forms and experts are divided over its precise function. On the one hand, some scholars point to industrial policy as a tool of *structural transformation* in sectors where countries already present a comparative advantage (Hausmann, Klinger, and Lawrence, 2008; J. Y. Lin, 2012). While markets remain the main mechanism for an effective allocation of resources, governments are called to prevent *information externalities* and *coordination failures* through the development of hard infrastructures, educational and health institutions, and a thriving legal and financial environment (Mbate, 2016; Stiglitz, Lin, Monga, and Patel, 2013). On the other hand, a different scholarship has argued for more aggressive institutional interventions aimed at *defying countries' comparative advantages* via direct regulation of imports, mandated above-market floor prices, subsidies, and technology transfer measures aimed at upgrading a country's industry (H.-J. Chang, 2013; 2014; P. Evans, 1995; Lall, 2000, UNECA, 2016)

Most proponents of *trade-induced innovation* via participation in global export markets and global value chains fall within the first group. These scholars do not jettison industrial policy all together, yet they conceive it as an instrument to favour firms' participation in global value chains rather than a strategy for "picking winners" (Gereffi and Sturgeon,

Footnotes

81. This occurs because, whilst production leads to pollution, pollution can be reduced by allocating some final production to its abatement (D. Stern, 2014).

2013; Milberg, Jiang, and Gereffi, 2014). Moreover, with the growth of trade in global value chains, manufacturing alone has been increasingly associated with lower gains from trade as an increasing number of suppliers, especially in developing countries, enters the value chain at this stage (Mudambi, 2008).

From an empirical perspective, whilst the association between economic growth, firm-productivity, and exports is widely acknowledged, evidence on whether *exporting* is a consequence or a cause of participation in global markets remains at best controversial (Alvarez and López, 2005; Bigsten and Gebreeyesus, 2009; Foster-McGregor, Isaksson, and Kaulich, 2014; Ranjan and Raychaudhuri, 2011; Yang and Mallick, 2010). In particular, some studies have pointed to how firms gain efficiency before rather than after entering export markets (Bernard and Jensen, 1999; Clerides, Lach, and Tybout, 1998; Graner and Isaksson, 2009; Gupta, Patnaik, and Shah, 2013; Haidar, 2012; Melitz, 2003; J. Wagner, 2007), suggesting a potential positive role for industrial policy in the process of *self-selection* and export promotion.

Concerning wages and labour standards, advocates of government intervention argue that innovation and labour demand do not alone lead to an increase in workers' remuneration, which is instead the outcome of a bargaining process between labour and management and the norms mediating such interaction (Milberg and Winkler, 2011; Selwyn, 2013). In a context dominated by global value chains, an unregulated market risks generating a *race to the bottom* where productivity is achieved by lowering labour costs. This is especially the case for labour-intensive sectors characterized by low entry barriers (Barrientos, Gereffi, and Rossi, 2011; Kaplinsky and Readman, 2005). *Immiserising growth* has been described in this sense as a situation where increasing output and employment is accompanied by falling economic returns and standards of living (Kaplinsky, 1998).

When it comes to the environmental challenges of trade liberalization, the issue remains an open debate. For instance, proponents of the pollution haven and industrial flight hypotheses predict a transfer of environmental externalities from high- to low-income countries with less stringent environmental regulations, a dynamic that has emerged in some case studies (Aliyu, 2005; Batrakova, 2012; K. P. Gallagher and Zarsky, 2007; Wagner and Timmins, 2009), though it is contested by others (Elliott and Shimamoto, 2008; Frankel and Rose, 2005; Grossman and Krueger, 1995). More recently, scholars pointed to the inconsistent empirical evidence supporting the EKC hypothesis and further argued in favour of a monotonic relationship between income and pollution (Anjum, Burke, Gerlach, and Stern, 2014; D. Stern, 2014; M. Wagner, 2008). Even though the *scale effect* is likely to be overturned in slow-growing economies with high per-capita income, this is unlikely to be the case in faster growing mid-income countries, where the impact of trade liberalization on economic growth tends to overturn the environmental benefits generated by increased access to ESTs (Jackson, 2016; Managi et al., 2009). In other words, it is unclear how trade liberalization would solve environmental externalities despite its potential to facilitate technology transfer.

Innovation diffusion occurs when new technologies reduce production costs and/or provide more desirable products to consumers. Yet, as argued by Copeland (2012), ESTs are often less cost-efficient than conventional technologies and environmentally friendly products more expensive and less desirable. Accordingly, while openness to trade is positively correlated with the adoption rate of new technologies, these are unlikely to be ESTs unless an incentive is put in place (Popp, Newell, and Jaffe, 2009). This argument is in line with the Porter hypothesis, according to which pollution generates a waste of resources that can be optimized through the adoption of ESTs. Yet, in a situation where risk aversion and asymmetric information prevent managers from adopting such technologies, more stringent environment regulations can realize the win-win outcome of reducing pollution levels and production costs (D.Mohr, 2002; Porter and Linde, 1995). Although empirical studies on the Porter hypothesis present mixed results, there is increasing evidence that specific policies to facilitate the adoption of ESTs can foster innovation and increase firms' competitive advantage (Ambec, 2017, p. 44).

Annex 8 – Benefits and challenges of EPPs

Table A8.1: Benefits of EPPs (UN Environment case studies)

Economic		Social		Environmental	
Opportunities	**Avoided costs**	**Opportunities**	**Avoided costs**	**Opportunities**	**Avoided costs**
• Increased access to global organic markets • Increased productivity (in some cases) • Premium market prices and reduced competition • Higher revenues from increased corporate reputation • Increased revenues in other sectors due to reduced externalities (fisheries, forestry) • Increased revenue from taxation and more fiscal resources for sectoral support	• Reduced use of fertilizers and pesticides • Reduced water intensity • Reduced productivity losses from soil degradation • Avoided costs of food subsidies as a results of increased food production • Reduced costs of groundwater purification	• Income generation for the rural population • Poverty reduction • Increased access to water and improved nutritional levels • Organic production evades the need to purchase agro-inputs, which empowers women to farm on an equal level • The extra income enables families to pay school fees.	• Reduced employment and income losses from soil degradation • Reduced health costs caused by malnutrition, water pollution. And exposure to pesticides • Reduced costs of urbanization due to the abandonment of agricultural land	• Improved soil quality • Forest preservation • Improved air and water quality • Protection of biocultural diversity	• Reduced greenhouse gas emissions • Reduced costs of water pollution

Source: **Author's elaboration based UNEP(2016b), UNEP(2015b), UNEP(2016a), UNEP(2016c)**

Table A8.2: Challenges of EPPs (UN Environment case studies)

Chile[82]	Capital and operation management costs of organic fertilisers, energy-efficient technologies, and extra labour-costs due to the higher need for skilled labour inputs Training costs of farmers in the use of sustainable technologies Certification costs for application fee, annual renewal fee, inspection and annual assessment fees Public costs including economic incentives for purchasing organic inputs, irrigation techniques, and investing in renewable energies Organic farming generates smaller yields (disputed)[83]
South Africa	Lack of harmonization: the growth in number and variety of organic standards can constrain further organic market development and hamper market access, often to the detriment of smallholders in developing countries Resources allocation: While benefits from exports offset costs, firms need to allocate resources and maintain sophisticated market intelligence Access to export markets: especially for smallholders, despite already practicing uncertified organic farming
Peru	Lack of knowledge: producers have little access to information about sustainability standards Lack of appropriate financial facilitating mechanisms for small-scale producers: The cost of the certification does not depend on the size of the producer's land. In most cases, the certification of farmers at the expense buyers leads to exclusivity contracts that disempower producers Lack of expertise: low levels of expertise constrain the upgrade of production methods and marketing processes Lack of effective market linkages: Value chain linkages between small producers and international buyers prevent market access
Viet Nam	Dependency on foreign markets: export volumes are over-dependent on actual demand in international markets (pangasius) Poor value chain linkages: low cooperation among producers leads to scattered production and "bad" competition across the sector Low technology and innovation: technological progress has not been sufficient to unleash the full potential of the sector Capacity of the private sector: the low quality of the labour force negatively affects the quality of products. In 2014 only 30% of the farmers fully used the manuals of feed, chemicals or medicine in aquaculture Capacity of the public sector: the collaboration between the ministries does not yet run smoothly due to an overlapping of tasks and the misuse of human resources Planning: the scattered character of the sector (characterized by several small producers) constrains certification, as it leads to higher costs. The individual format (household) of aquaculture means that the production land is quite scattered Infrastructure: absence of realistic development plans, insufficient resources for investment, and spontaneous development of farming activities

Source: **Author's elaboration based on UNEP (2016b), UNEP (2015b), UNEP (2016a), UNEP (2016c).**

Footnotes

82. The same challenges are reported for South Africa.
83. According to the FAO Inter-departmental Working Group on Organic Agriculture, organic techniques decrease yields in developed economies. Nevertheless, in traditional rain-fed agriculture with low-input external inputs, organic agriculture has the potential to increase yields (UNEP, 2016c).

Annex 9 – List of SDG targets

Table A9.1: List of Sustainable Development Goals and their targets

Goal	Targets
Goal 1: End poverty in all its forms everywhere	**1.1** By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day **1.2** By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions implement nationally appropriate social protection systems and measure for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable **1.3** Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable **1.4** By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance **1.5** By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters **1.A** Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions **1.B** Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	**2.1** By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round. **2.2** By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons. **2.3** By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment. **2.4** By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality. **2.5** By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed. **2.A** Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries. **2.B** Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round. **2.C** Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.

Goal 3: Ensure healthy lives and promote well-being for all at all ages	**3.1** By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births. **3.2** By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births. **3.3** By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases. **3.4** By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being. **3.5** Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol. **3.6** By 2020, halve the number of global deaths and injuries from road traffic accidents. **3.7** By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes. **3.8** Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all. **3.9** By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination. **3.A** Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate. **3.B** Support the research and development of vaccines and medicines for the communicable and noncommunicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all. **3.C** Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States. **3.D** Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	**4.1** By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and Goal-4 effective learning outcomes **4.2** By 2030, ensure that all girls and boys have access to quality early childhood development, care and preprimary education so that they are ready for primary education **4.3** By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university **4.4** By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship **4.5** By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations **4.6** By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy **4.7** By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development **4.A** Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, nonviolent, inclusive and effective learning environments for all **4.B** By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries **4.C** By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing states
Goal 5: Achieve gender equality and empower all women and girls	**5.1** End all forms of discrimination against all women and girls everywhere **5.2** Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation **5.3** Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation **5.4** Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate **5.5** Ensure women's full and effective participation and equal opportunities for leadership at all levels of decisionmaking in political, economic and public life **5.6** Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences **5.A** Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws **5.B** Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women **5.C** Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels

Goal 6: Ensure availability and sustainable management of water and sanitation for all	**6.1** By 2030, achieve universal and equitable access to safe and affordable drinking water for all **6.2** By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations **6.3** By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally **6.4** By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity **6.5** By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate **6.6** By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes **6.A** By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies **6.B** Support and strengthen the participation of local communities in improving water and sanitation management
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	**7.1** By 2030, ensure universal access to affordable, reliable and modern energy services **7.2** By 2030, increase substantially the share of renewable energy in the global energy mix **7.3** By 2030, double the global rate of improvement in energy efficiency **7.A** By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology **7.B** By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	**8.1** Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries **8.2** Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors **8.3** Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services **8.4** Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead **8.5** By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value **8.6** By 2020, substantially reduce the proportion of youth not in employment, education or training **8.7** Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms **8.8** Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment **8.9** By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products **8.10** Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all **8.A** Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries **8.B** By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	**9.1** Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all **9.2** Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries **9.3** Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets **9.4** By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities **9.5** Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending **9.A** Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States 18 **9.B** Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities **9.C** Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020

Goal 10: Reduce inequality within and among countries	**10.1** By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average **10.2** By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status **10.3** Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard **10.4** Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality **10.5** Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations **10.6** Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions **10.7** Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies **10.A** Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements **10.B** Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes **10.C** By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	**11.1** By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums **11.2** By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons **11.3** By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries **11.4** Strengthen efforts to protect and safeguard the world's cultural and natural heritage **11.5** By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations **11.6** By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management **11.7** By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities **11.A** Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning **11.B** By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels **11.C** Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials
Goal 12: Ensure sustainable consumption and production patterns	**12.1** Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries **12.2** By 2030, achieve the sustainable management and efficient use of natural resources **12.3** By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses **12.4** By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment **12.5** By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse **12.6** Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle **12.7** Promote public procurement practices that are sustainable, in accordance with national policies and priorities **12.8** By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature **12.A** Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production **12.B** Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products **12.C** Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities

Goal 13: Take urgent action to combat climate change and its impacts*	**13.1** Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries **13.2** Integrate climate change measures into national policies, strategies and planning **13.3** Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning **13.A** Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible **13.B** Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities **Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, inter governmental forum for negotiating the global response to climate change.*
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	**14.1** By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution **14.2** By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans **14.3** Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels **14.4** By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics **14.5** By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information **14.6** By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation **14.7** By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism **14.A** Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries **14.B** Provide access for small-scale artisanal fishers to marine resources and markets **14.C** Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	**15.1** By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements **15.2** By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally **15.3** By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world **15.4** By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development **15.5** Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species **15.6** Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed **15.7** Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products **15.8** By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species **15.9** By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts **15.A** Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems **15.B** Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation **15.C** Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	**16.1** Significantly reduce all forms of violence and related death rates everywhere **16.2** End abuse, exploitation, trafficking and all forms of violence against and torture of children **16.3** Promote the rule of law at the national and international levels and ensure equal access to justice for all **16.4** By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime **16.5** Substantially reduce corruption and bribery in all their forms **16.6** Develop effective, accountable and transparent institutions at all levels **16.7** Ensure responsive, inclusive, participatory and representative decision-making at all levels **16.8** Broaden and strengthen the participation of developing countries in the institutions of global governance **16.9** By 2030, provide legal identity for all, including birth registration **16.10** Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements **16.A** Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime **16.B** Promote and enforce non-discriminatory laws and policies for sustainable development

Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development	*Finance* **17.1** Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection **17.2** Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of ODA/GNI to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries **17.3** Mobilize additional financial resources for developing countries from multiple sources **17.4** Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress **17.5** Adopt and implement investment promotion regimes for least developed countries *Technology* **17.6** Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism **17.7** Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed **17.8** Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology *Capacity building* **17.9** Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation *Trade* **17.10** Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda **17.11** Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020 **17.12** Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access ***Systemic issues*** *Policy and institutional coherence* **17.13** Enhance global macroeconomic stability, including through policy coordination and policy coherence **17.14** Enhance policy coherence for sustainable development **17.15** Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development *Multi-stakeholder partnerships* **17.16** Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries **17.17** Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships *Data, monitoring and accountability* **17.18** By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts **17.19** By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries

Annex 10 – Trade analysis of natural fibres

Table A10.1: Global trade in natural fibres in 2016 (in USD million)

Panel A: Top 5 importers and exporters of hemp products							
530210, Hemp; raw or retted, but not spun				**530820, Yarn; of hemp**			
Importers		**Exporters**		**Importers**		**Exporters**	
Czechia	3.49	Netherlands	0.46	USA	1.96	China	1.06
Germany	1.72	USA	0.28	Korea	0.42	Italy	0.73
Slovenia	0.35	Romania	0.18	China	0.39	Colombia	0.54
USA	0.19	Ukraine	0.12	Japan	0.23	China	0.37
UK	0.13	China	0.12	France	0.22	Austria	0.18

Panel B: Total global imports and exports of hemp products					
HS-6 code	**End-use**	**Total**	**Imports**	**Exports**	**Balance**
530210	Hemp; raw or retted, but not spun	8.1	3.6	1.7	-2.0
530820	Yarn; of hemp	8.9	5.2	3.6	-1.6

Source: **based on authors calculations of Comtrade data**

Annex 11 – MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs

Germany (CET for EU; 2016)							
HS6 code	Product Name	Category	Type	Simple Avg.	Min Rate	Max Rate	# of dutiable lines
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Applied	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Bound	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	MFN	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	1.41	0	4.5	5
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	4.5	4.5	4.5	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	4.5	4.5	4.5	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	2.25	0	4.5	4
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	4.5	4.5	4.5	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	4.5	4.5	4.5	1
Japan (2016)							
HS6 code	Product Name	Category	Type	Simple Avg.	Min Rate	Max Rate	# of dutiable lines

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Applied	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Bound	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	MFN	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	0	0	0	0
841090	Parts for hydraulic turbines	RE	Applied	0	0	0	0
841090	Parts for hydraulic turbines	RE	Bound	0	0	0	0
841090	Parts for hydraulic turbines	RE	MFN	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	0	0	0	0
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	0	0	0	0
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound	0	0	0	0
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	0	0	0	0
850231	Wind-powered electricity generating sets	RE	Applied	0	0	0	0

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

850231	Wind-powered electricity generating sets	RE	Bound	0	0	0	0
850231	Wind-powered electricity generating sets	RE	MFN	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Bound	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	0	0	0	0
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound	0	0	0	0
854140	PV module, wafers, cells	RE	MFN	0	0	0	0
USA (2016)							
HS6 code	Product Name	Category	Type	Simple Avg.	Min Rate	Max Rate	# of dutiable lines
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Applied	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Bound	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	MFN	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	3.04	0	3.8	8
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	3.8	3.8	3.8	1

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	3.8	3.8	3.8	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	2.28	0	3.8	3
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	3.8	3.8	3.8	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	3.8	3.8	3.8	1
841090	Parts for hydraulic turbines	RE	Applied	2.58	0	3.8	19
841090	Parts for hydraulic turbines	RE	Bound	3.8	3.8	3.8	1
841090	Parts for hydraulic turbines	RE	MFN	3.8	3.8	3.8	1
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	0	0	0	0
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	0	0	0	0
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound	0	0	0	0
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	0	0	0	0
850231	Wind-powered electricity generating sets	RE	Applied	0.95	0	2.5	16
850231	Wind-powered electricity generating sets	RE	Bound	1.25	0	2.5	1
850231	Wind-powered electricity generating sets	RE	MFN	1.25	0	2.5	1
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	1.57	0	6.5	196
850300	Parts for electricity generators (incl heading 8502)	RE	Bound	3.06	0	6.5	5
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	3.06	0	6.5	5
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	0.87	0	1.3	22
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound	0.65	0	1.3	1
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	1.3	1.3	1.3	1
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound	0	0	0	0
854140	PV module, wafers, cells	RE	MFN	0	0	0	0

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

Brazil (2016)							
HS6 code	Product Name	Category	Type	Simple Avg.	Min Rate	Max Rate	# of dutiable lines
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	8	8	8	2
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	35	35	35	3
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	8	8	8	2
530390	Other Jute and other textile bast fibres	EPPs	Applied	8	8	8	4
530390	Other Jute and other textile bast fibres	EPPs	Bound	35	35	35	2
530390	Other Jute and other textile bast fibres	EPPs	MFN	8	8	8	2
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	6	6	6	2
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	35	35	35	11
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	6	6	6	2
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	14	14	14	6
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	35	35	35	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	14	14	14	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	14	14	14	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	35	35	35	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	14	14	14	1
841090	Parts for hydraulic turbines	RE	Applied	14	14	14	19
841090	Parts for hydraulic turbines	RE	Bound	30	25	35	2
841090	Parts for hydraulic turbines	RE	MFN	14	14	14	1
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	8.4	0	14	192
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound	35	35	35	5
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	8.4	0	14	3
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	11.5	0	18	180
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound	35	35	35	4

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	11.5	0	18	3
850231	Wind-powered electricity generating sets	RE	Applied	0	0	0	0
850231	Wind-powered electricity generating sets	RE	Bound	35	35	35	1
850231	Wind-powered electricity generating sets	RE	MFN	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	14	14	14	116
850300	Parts for electricity generators (incl heading 8502)	RE	Bound	30	25	35	4
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	14	14	14	2
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	14	14	14	100
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound	35	35	35	5
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	14	14	14	5
854140	PV module, wafers, cells	RE	Applied	4.44	0	12	531
854140	PV module, wafers, cells	RE	Bound	19.44	0	35	10
854140	PV module, wafers, cells	RE	MFN	4.44	0	12	9
China (2015)							
HS6 code	**Product Name**	**Category**	**Type**	**Simple Avg.**	**Min Rate**	**Max Rate**	**# of dutiable lines**
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	5	5	5	4
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	5	5	5	1
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	5	5	5	1
530390	Other Jute and other textile bast fibres	EPPs	Applied	5	5	5	2
530390	Other Jute and other textile bast fibres	EPPs	Bound	5	5	5	1
530390	Other Jute and other textile bast fibres	EPPs	MFN	5	5	5	1
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	4.75	3	5	120
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	4.64	3	5	11
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	4.75	3	5	8

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	10	10	10	3
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	10	10	10	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	10	10	10	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	10	10	10	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	10	10	10	1
841090	Parts for hydraulic turbines	RE	Applied	6	6	6	24
841090	Parts for hydraulic turbines	RE	Bound	6	6	6	2
841090	Parts for hydraulic turbines	RE	MFN	6	6	6	2
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	5	5	5	126
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound	5	5	5	2
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	5	5	5	2
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	6	5	15	720
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound	6.67	5	15	6
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	6	5	15	10
850231	Wind-powered electricity generating sets	RE	Applied	8	8	8	14
850231	Wind-powered electricity generating sets	RE	Bound	8	8	8	1
850231	Wind-powered electricity generating sets	RE	MFN	8	8	8	1
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	6.5	3	12	288
850300	Parts for electricity generators (incl heading 8502)	RE	Bound	6.5	3	12	4
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	6.5	3	12	4
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	0	0	0	0
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound	0	0	0	0

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

854140	PV module, wafers, cells	RE	MFN	0	0	0	0
India (2016)							
HS6 code	Product Name	Category	Type	Simple Avg.	Min Rate	Max Rate	# of dutiable lines
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	6	0	10	8
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	40	40	40	1
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	7.5	5	10	2
530390	Other Jute and other textile bast fibres	EPPs	Applied	7.5	0	10	6
530390	Other Jute and other textile bast fibres	EPPs	Bound	40	40	40	1
530390	Other Jute and other textile bast fibres	EPPs	MFN	10	10	10	2
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	7.27	0	10	48
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	40	40	40	1
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	10	10	10	6
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	7.5	7.5	7.5	3
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	25	25	25	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	7.5	7.5	7.5	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	7.5	7.5	7.5	2
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	25	25	25	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	7.5	7.5	7.5	2
841090	Parts for hydraulic turbines	RE	Applied	7.5	7.5	7.5	16
841090	Parts for hydraulic turbines	RE	Bound	25	25	25	1
841090	Parts for hydraulic turbines	RE	MFN	7.5	7.5	7.5	1
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	7.5	7.5	7.5	59
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound	40	40	40	1
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	7.5	7.5	7.5	1

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	7.5	7.5	7.5	189
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound	40	40	40	1
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	7.5	7.5	7.5	3
850231	Wind-powered electricity generating sets	RE	Applied	7.5	7.5	7.5	8
850231	Wind-powered electricity generating sets	RE	Bound	25	25	25	1
850231	Wind-powered electricity generating sets	RE	MFN	7.5	7.5	7.5	1
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	7.38	0	7.5	236
850300	Parts for electricity generators (incl heading 8502)	RE	Bound	25	25	25	2
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	7.5	7.5	7.5	4
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	7.5	7.5	7.5	64
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound	25	25	25	1
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	7.5	7.5	7.5	2
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound	0	0	0	0
854140	PV module, wafers, cells	RE	MFN	0	0	0	0
Mexico (2016)							
HS6 code	**Product Name**	**Category**	**Type**	**Simple Avg.**	**Min Rate**	**Max Rate**	**# of dutiable lines**
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	35	35	35	1
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Applied	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Bound	35	35	35	1
530390	Other Jute and other textile bast fibres	EPPs	MFN	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	0	0	0	0

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	35	35	35	1
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	35	35	35	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	35	35	35	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	0	0	0	0
841090	Parts for hydraulic turbines	RE	Applied	0	0	0	0
841090	Parts for hydraulic turbines	RE	Bound	35	35	35	1
841090	Parts for hydraulic turbines	RE	MFN	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	1.11	0	5	170
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound	35	35	35	1
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	1.11	0	5	2
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	1.67	0	5	267
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound	35	35	35	1
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	1.67	0	5	3
850231	Wind-powered electricity generating sets	RE	Applied	2.5	0	5	19
850231	Wind-powered electricity generating sets	RE	Bound	35	35	35	1
850231	Wind-powered electricity generating sets	RE	MFN	2.5	0	5	1
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Bound	35	35	35	1
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	2.14	0	15	36
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound	33.57	25	35	7

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	2.14	0	15	1
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound	35	35	35	1
854140	PV module, wafers, cells	RE	MFN	0	0	0	0
Russia (2016)							
HS6 code	**Product Name**	**Category**	**Type**	**Simple Avg.**	**Min Rate**	**Max Rate**	**# of dutiable lines**
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	5	5	5	1
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	5	5	5	1
530390	Other Jute and other textile bast fibres	EPPs	Applied	1.13	0	2.25	1
530390	Other Jute and other textile bast fibres	EPPs	Bound	3	3	3	1
530390	Other Jute and other textile bast fibres	EPPs	MFN	3	3	3	1
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	2.39	0	3	10
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	3	3	3	1
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	3	3	3	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	15	15	15	5
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	15	15	15	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	15	15	15	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	13	13	13	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	13	13	13	1
841090	Parts for hydraulic turbines	RE	Applied	10.45	0	15	26
841090	Parts for hydraulic turbines	RE	Bound	15	15	15	3
841090	Parts for hydraulic turbines	RE	MFN	11.25	7.5	15	2
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	0.91	0	3	64

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound	4.33	3	5	3
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	1	0	3	1
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	0.37	0	2	64
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound	4	2	5	9
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	0.4	0	2	1
850231	Wind-powered electricity generating sets	RE	Applied	0	0	0	0
850231	Wind-powered electricity generating sets	RE	Bound	5	5	5	1
850231	Wind-powered electricity generating sets	RE	MFN	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Bound	5	5	5	3
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound	5	5	5	2
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	0	0	0	0
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound	0	0	0	0
854140	PV module, wafers, cells	RE	MFN	0	0	0	0
South Africa (2016)							
HS6 code	**Product Name**	**Category**	**Type**	**Simple Avg.**	**Min Rate**	**Max Rate**	**# of dutiable lines**
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Applied	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Bound	0	0	0	0

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

530390	Other Jute and other textile bast fibres	EPPs	MFN	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	0	0	0	0
841090	Parts for hydraulic turbines	RE	Applied	0	0	0	0
841090	Parts for hydraulic turbines	RE	Bound	0	0	0	0
841090	Parts for hydraulic turbines	RE	MFN	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound	15	15	15	1
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	0	0	0	0
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	3.33	0	19	40
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound	25	15	30	3
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	6.33	0	19	1
850231	Wind-powered electricity generating sets	RE	Applied	0	0	0	0
850231	Wind-powered electricity generating sets	RE	Bound	20	20	20	1
850231	Wind-powered electricity generating sets	RE	MFN	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	5	0	15	160
850300	Parts for electricity generators (incl heading 8502)	RE	Bound	15	15	15	1
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	10	5	15	5

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	0	0	0	0
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound	10	10	10	1
854140	PV module, wafers, cells	RE	MFN	0	0	0	0
Mozambique (2016)							
HS6 code	**Product Name**	**Category**	**Type**	**Simple Avg.**	**Min Rate**	**Max Rate**	**# of dutiable lines**
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound				0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	2.5	2.5	2.5	1
530390	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Bound				0
530390	Other Jute and other textile bast fibres	EPPs	MFN	2.5	2.5	2.5	1
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	1.25	0	2.5	1
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound				0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	2.5	2.5	2.5	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	1.67	0	5	1
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound				0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	5	5	5	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	2.5	0	5	1
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound				0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	5	5	5	1
841090	Parts for hydraulic turbines	RE	Applied	1.43	0	5	2
841090	Parts for hydraulic turbines	RE	Bound	5	5	5	1

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

841090	Parts for hydraulic turbines	RE	MFN	5	5	5	1
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	2.73	0	5	18
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound				0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	5	5	5	1
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	3.14	0	5	22
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound				0
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	5	5	5	1
850231	Wind-powered electricity generating sets	RE	Applied	2.5	0	5	1
850231	Wind-powered electricity generating sets	RE	Bound				0
850231	Wind-powered electricity generating sets	RE	MFN	5	5	5	1
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	2.41	0	5	14
850300	Parts for electricity generators (incl heading 8502)	RE	Bound				0
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	5	5	5	1
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	2.5	0	5	9
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound				0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	5	5	5	1
854140	PV module, wafers, cells	RE	Applied	3.95	0	7.5	10
854140	PV module, wafers, cells	RE	Bound				0
854140	PV module, wafers, cells	RE	MFN	7.5	7.5	7.5	1
Tanzania (2016)							
HS6 code	**Product Name**	**Category**	**Type**	**Simple Avg.**	**Min Rate**	**Max Rate**	**# of dutiable lines**
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Applied	0	0	0	0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound				0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	0	0	0	0

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

530390	Other Jute and other textile bast fibres	EPPs	Applied	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Bound				0
530390	Other Jute and other textile bast fibres	EPPs	MFN	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound				0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound				0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Applied	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound				0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	0	0	0	0
841090	Parts for hydraulic turbines	RE	Applied	0	0	0	0
841090	Parts for hydraulic turbines	RE	Bound				0
841090	Parts for hydraulic turbines	RE	MFN	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	9.6	0	10	48
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound				0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	10	10	10	1
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	4.9	0	10	47
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound				0
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	5	0	10	1
850231	Wind-powered electricity generating sets	RE	Applied	0	0	0	0
850231	Wind-powered electricity generating sets	RE	Bound				0
850231	Wind-powered electricity generating sets	RE	MFN	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	0	0	0	0

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

850300	Parts for electricity generators (incl heading 8502)	RE	Bound				0
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound				0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	0	0	0	0
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound				0
854140	PV module, wafers, cells	RE	MFN	0	0	0	0
Uganda (2016)							
HS6 code	**Product Name**	**Category**	**Type**	**Simple Avg.**	**Min Rate**	**Max Rate**	**# of dutiable lines**
530310	Jute and other textile bast fibres (raw, netted)	EPPs	Bound				0
530310	Jute and other textile bast fibres (raw, netted)	EPPs	MFN	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Applied	0	0	0	0
530390	Other Jute and other textile bast fibres	EPPs	Bound				0
530390	Other Jute and other textile bast fibres	EPPs	MFN	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Applied	0	0	0	0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	Bound				0
530500	Coconut, abaca, ramie and other vegetable textile fibres	EPPs	MFN	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Applied	0	0	0	0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	Bound				0
841011	Micro-hydro turbines (not exceeding 1000kW)	RE	MFN	0	0	0	0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	Bound				0
841012	Small-hydro turbines (exceeding 1000kW but not exceeding 10000kW)	RE	MFN	0	0	0	0
841090	Parts for hydraulic turbines	RE	Applied	0	0	0	0

Table A11.1: A11.1: MFN applied and bound tariffs for selected EST-EGs (with clearer environmental end-use) and EPPs for selected top trading countries among developed and developing countries, including BRIC countries and LDCs (continued)

841090	Parts for hydraulic turbines	RE	Bound				0
841090	Parts for hydraulic turbines	RE	MFN	0	0	0	0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Applied	9.31	0	10	27
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	Bound				0
842129	Filtering or purifying machinery and apparatus for liquids	WMWT	MFN	10	10	10	1
842139	Filtering or purifying machinery and apparatus for gases	APC	Applied	4.8	0	10	24
842139	Filtering or purifying machinery and apparatus for gases	APC	Bound				0
842139	Filtering or purifying machinery and apparatus for gases	APC	MFN	5	0	10	1
850231	Wind-powered electricity generating sets	RE	Applied	0	0	0	0
850231	Wind-powered electricity generating sets	RE	Bound				0
850231	Wind-powered electricity generating sets	RE	MFN	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Applied	0	0	0	0
850300	Parts for electricity generators (incl heading 8502)	RE	Bound				0
850300	Parts for electricity generators (incl heading 8502)	RE	MFN	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Applied	0	0	0	0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	Bound				0
851430	Waste incinerators or other (heat) waste treatment apparatus	SHWM	MFN	0	0	0	0
854140	PV module, wafers, cells	RE	Applied	0	0	0	0
854140	PV module, wafers, cells	RE	Bound				0
854140	PV module, wafers, cells	RE	MFN	0	0	0	0

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